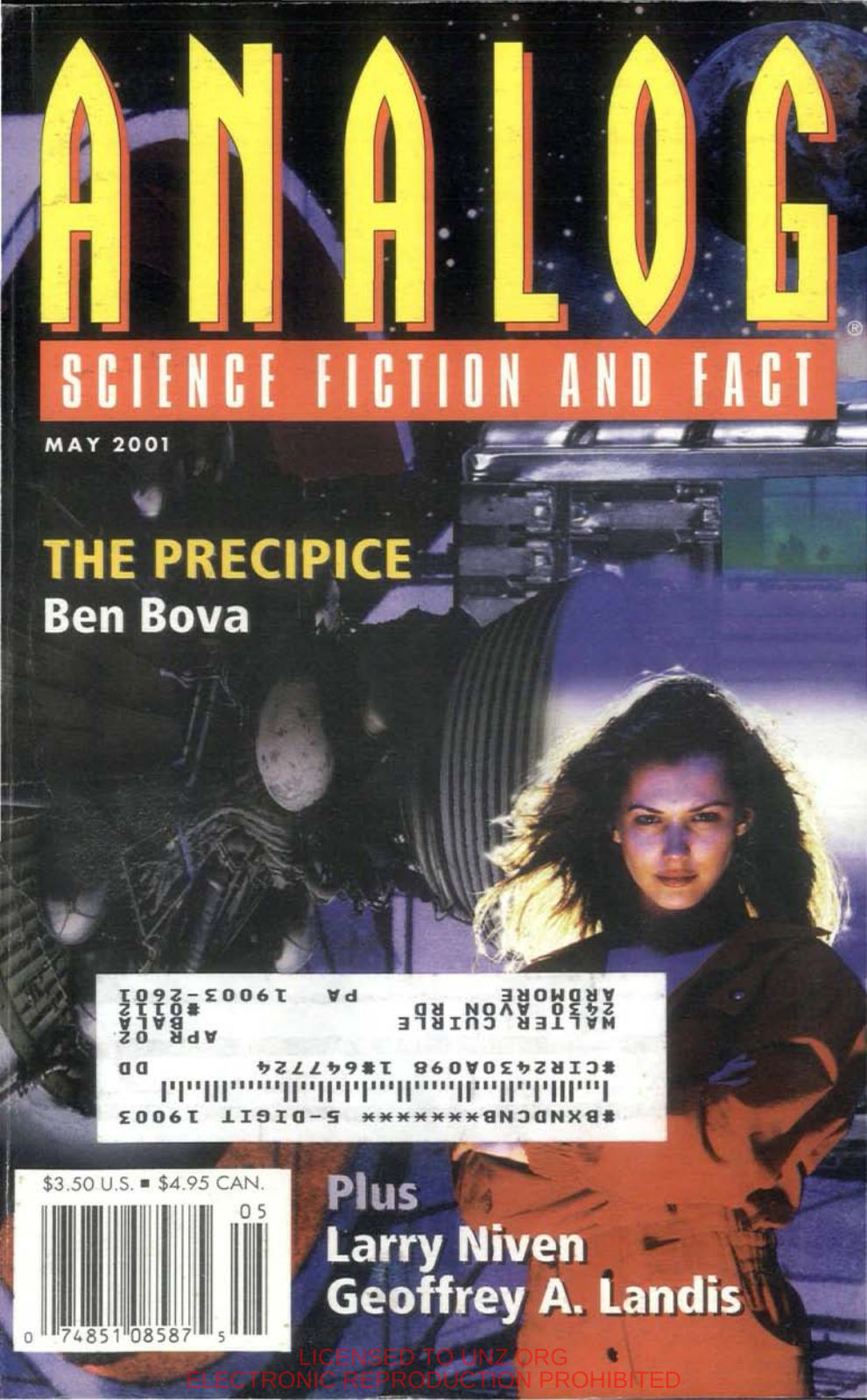

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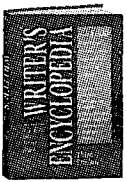

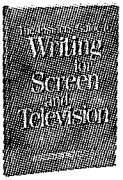

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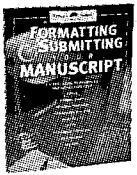

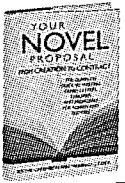

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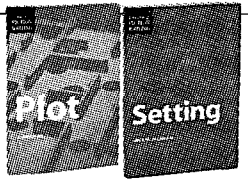

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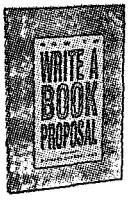

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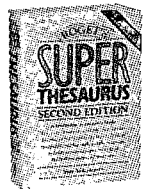

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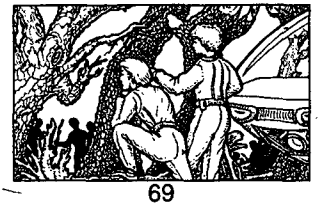

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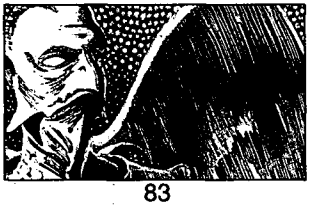

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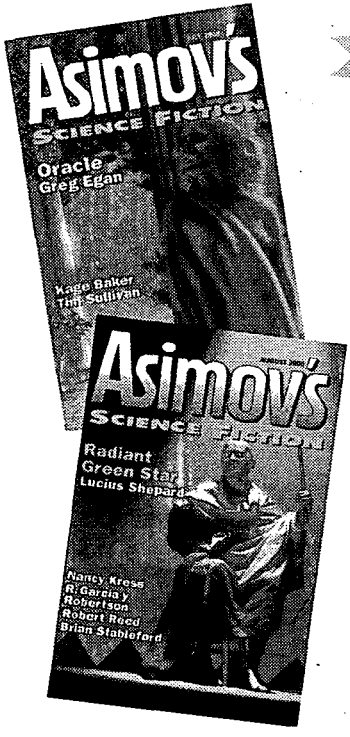

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EDITORIAL Stanley Schmidt

A PERFECT FIT

Much of human history can be viewed as the process of individuals and societies adapting to their environment—and vice versa. They adapt to their environment, for example, by learning to hunt or fish, or by domesticating animals and building vehicles. They adapt their environment to themselves by such means as converting forest to farmland, or building roads.

The examples illustrate that sometimes either approach can be applied to the same problem—e.g., hunting and farming are both ways to insure a food supply, while vehicles and roads are both ways to make it easier to get from point A to point B. Sometimes both approaches can be combined to obtain a better fit between people and environment than either would yield alone. A horse, with or without a carriage, makes for an easier trip than walking. Build a road, so horses and carriages have a smooth, unimpeded right of way, and it gets even easier.

The same problem can often be solved, at least partially, by attacks on any of two or more levels, singly or in combination. As warm-blooded animals, for example, we need to maintain the temperatures of our bodies and immediate environments within a fairly narrow range—and the closer we can hold it to a quite narrow "comfort zone," the better. This goal can be achieved at the individual level by clothing, or at the environmental level (on a relatively small scale) by houses with heat and/or air-conditioning. Often, of course, both approaches are used together: people in industrialized countries commonly use clothing *and* heat or air-conditioning.

Advances in science and technology can expand the range of options at both ends. Genetic engineering is beginning to open up the possibility of modifying people themselves to fit particular environmental conditions. Science fiction has long explored the possibility of "terraforming," or modifying an entire planet to make it more congenial to humans. Either or both of these approaches may become increasingly important in real life if the Earth undergoes large-scale climate change, whether through careless human tampering or through natural effects such as long-range solar cycles.

Often most people can agree on what constitutes an improvement. For example, almost everyone would agree that clean water is better than filthy, and that temperatures around 20 C are better (for us) than 2 or 200 C. But all people are not created exactly equal, and still less do they stay that way forever. We may all like temperatures "around 20 C," but individuals with slightly different metabolisms may prefer them—sometimes strongly—as low as 15 or as high as 30. Thus we get the well-known "thermostat wars" when such individuals share housing—and the sweater and thermal underwear industries.

Which provides a gentle introduction to the recurring question of how to accommodate people with different needs. People who tend to feel hot or

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cold are a mild example of the problem, which most people (at least those not directly involved) would agree is most simply and reasonably solved by setting the thermostat low and having the "cold" person wear extra warm clothing. Those who *are* directly involved often don't see it that way—people being people, they're just as likely to waste time and energy snarling at each other for being "unreasonable."

So what do you do when people have *really* different needs—when, for example, some can see or walk and others can't? To what extent should people with unusual needs be expected to adapt themselves to the environment, with or without technological aids? And to what extent should the environment be adapted to them?

Again, either or both approaches can often be used. Sometimes it's quite reasonable and desirable to make some adjustments to the environment to make it more congenial to people with fairly common special needs. Crutches and wheelchairs constitute individual adaptations to mobility problems, but ramps and elevators make them a lot easier to use, so it makes good sense for cities to routinely build ramps or elevators as alternatives to curbs or stairs. They hurt nobody, and they help enough people to be worth the relatively small extra expense.

They don't necessarily make sense everywhere, though. The Appalachian Trail is a 2000-mile hiking trail running through the Appalachian Mountains, mostly along ridgecrests, from Georgia to Maine. The organization responsible for administering it has recently had to worry about the question of whether the law really requires the trail to be "universally accessible," which would be a nightmare (if not impossible) to make happen—and even if it were practical, would, in the opinion of most of its users, defeat one of its main purposes.

No, I *don't* mean to suggest that one of its main purposes is to discriminate against anybody. But most of its users regard it as both a means of getting into wild country, and a personal challenge. I can testify from personal experience that completing a sizable chunk of it solely with your own resources provides huge psychological rewards—which would be considerably diminished if the whole thing were made Easy Enough for All. I think the world needs to keep some places that can do that—even if it ever becomes practical to eliminate them all. (Of course, even from a practical standpoint it would make little sense to make the whole trail accessible. As a handicapped member of the Appalachian Trail Conference pointed out, few, if any, wheelchair users would ever venture very far from roads; so smoothing just short sections near roads would supply some access to wild places, while preserving varying levels of challenge elsewhere.)

Sometimes it's clearly better to adjust

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the atypical individual to the environment than vice versa. If one person has trouble hearing sounds that most people find comfortable, most would agree that it makes more sense to fit that person with a hearing aid than to amplify everything possible to levels painful for everyone else. Vision is perhaps an even clearer example. Yes, we can insist on adequate light levels (for most people) in public places; but refraction problems are so complex and individual that they *must* be solved on a case-by-case basis with individually fitted corrective lenses.

But the choice between individual and collective or environmental action is not always that straightforward, and our current society does not always see clearly when it has to decide between adjusting the individual and the environment. Sometimes it gets carried away with "accommodating special needs" in a way that looks altruistic, but in fact hurts not only the typical majority, but the atypical "beneficiary."

One of the more striking examples to come to my attention was the recent case of a school debating whether to ban peanuts from school premises—because one (1!) student was allergic to them. No peanut products—peanuts shelled or unshelled, peanut butter and jelly sandwiches, M&Ms, etc.—would be sold in the school cafeteria or vending machines. Parents of *all* students would be asked not to pack any such items in their children's lunches. (The board considered an outright ban, but couldn't quite bring themselves to go that far.)

All this, affecting *every* student in the school, to protect *one* of them from possible exposure to an allergen.

Now, I am *not* trying to minimize the seriousness of the student's allergy. I would never laugh dismissively, as I'm told some have, and say, "It's just peanut butter!" For the unfortunate student with the allergy, it is *not* "just peanut butter." Very small exposures can have very serious consequences, up to and including death. For the person who has it, that allergy is a very serious problem indeed—but it's his (or her) problem, not everybody else's.

Artificially making it everybody else's problem does the allergic child a small, short-term favor, and a large, long-range disservice. It tacitly teaches that the world will make itself safe for him—and it won't. The rest of the world will *not* see to it that no molecule from a peanut will ever get near him. That child *must* learn, as early as possible, that he alone

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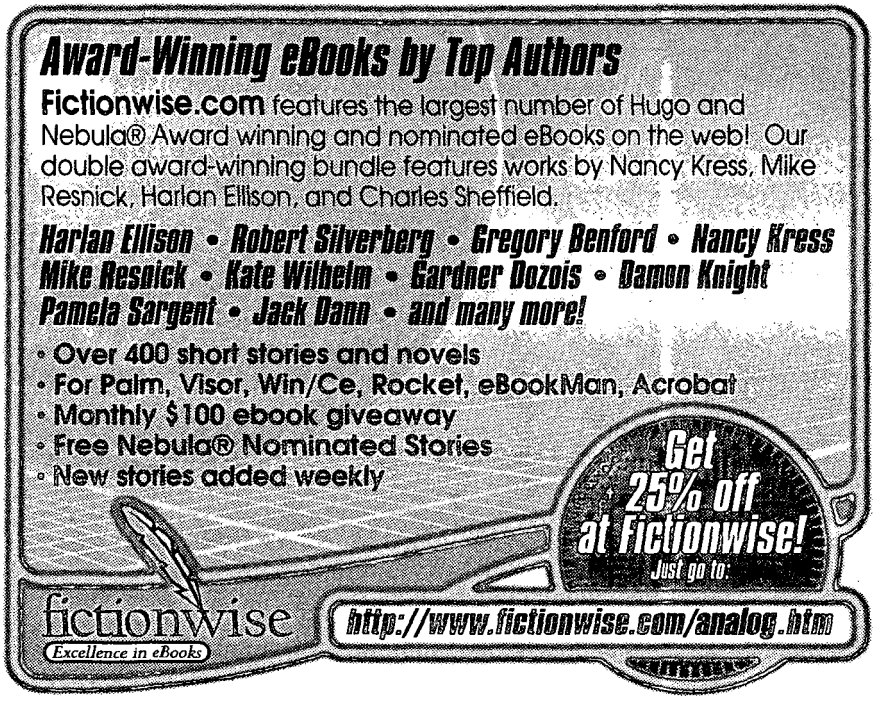
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is responsible for staying away from peanuts, no matter what. School provides an excellent opportunity to do that—but not by providing an artificial microcosm in which, unlike the rest of the world, the danger does not exist.

It would be far more helpful in the long run to make the school a microcosm in which the danger *does* exist, just as it does elsewhere, but the child is surrounded by people who have more than the average dedication to helping him learn to avoid it. His parents can start teaching what he can and what he must not do even before he goes to school. Once he gets there, his teachers can explain to the entire class that one of its members has a special problem and needs the help of every one of them to deal with it. The teachers can explain *how* they can help—from not offering that child peanuts or eating them near him, to warning him if they see him starting to eat something dangerous—and stress the extreme importance of these things. Yes, some danger will still exist—but at a level far more conducive to actually preparing him to live with it in the outside world. And this approach has the beneficial side effect of giving the entire class a valuable lesson in the importance of watching out for each other.

A perfect fit between everybody and the environment is a noble goal, but not achievable. Sometimes we just have to do the best we can, and just what that is is not always simple or obvious. ■

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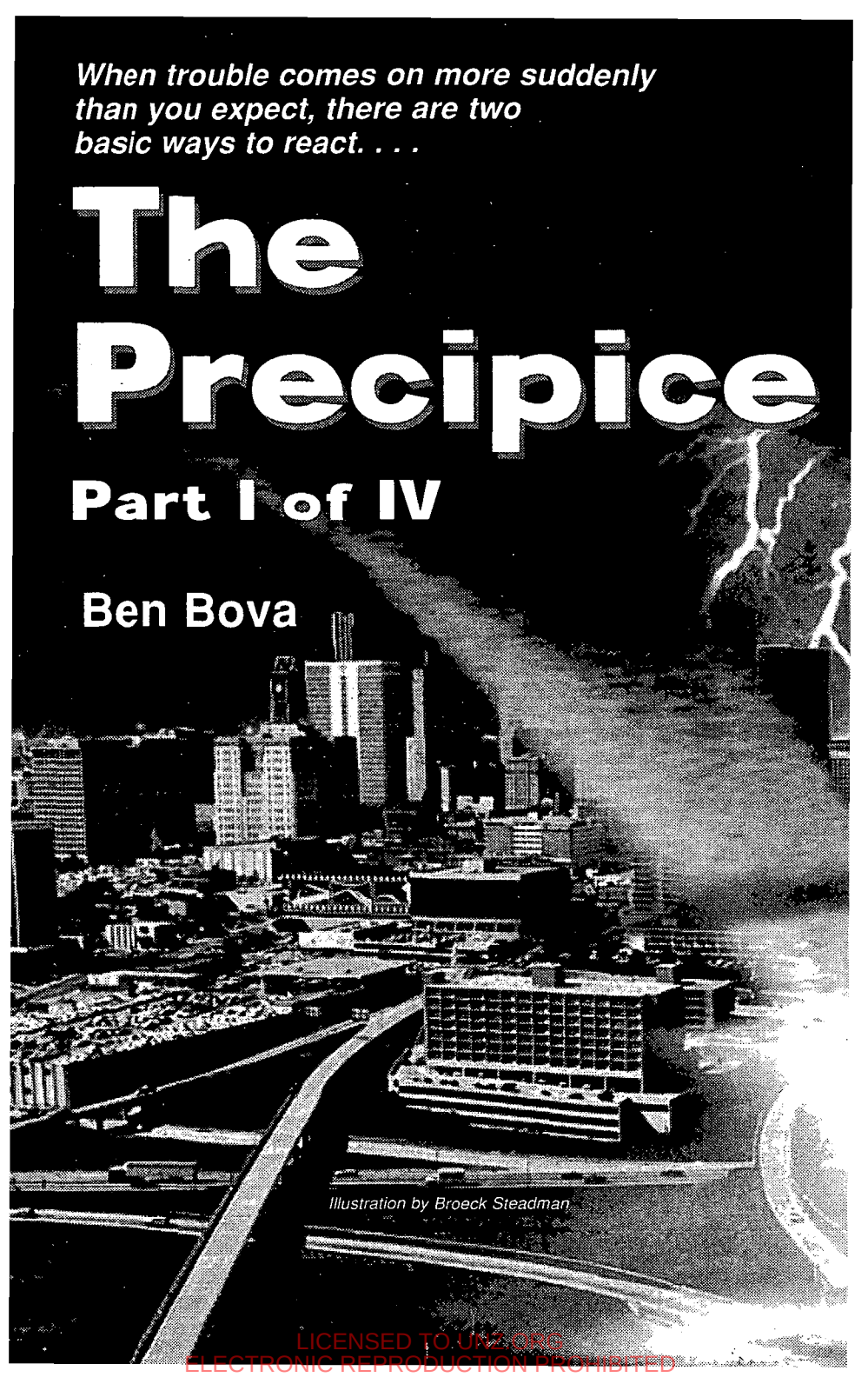
When trouble comes on more suddenly than you expect, there are two basic ways to react. . . .

The Precipice

Part I of IV

Ben Bova



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MEMPHIS

"Jesus," the pilot kept murmuring. "Jesus, Jesus, Jesus."

The helicopter was racing north, bucking, jolting between the shattered land below and the thick dark gray clouds scudding just above, trying to follow Interstate 55 from the Memphis International Airport to what was left of the devastated city.

You could not see the highway; it was carpeted from horizon to horizon with refugees, bumper to bumper traffic inching along, an unending stream of cars, trucks, vans, buses, people on foot swarming like ants, trudging painfully along the shoulders of the road in the driving, soaking rain, women pushing baby carriages, men and boys hauling carts piled high with whatever they could salvage from their homes. Flood water was lapping along the shoulder embankment, rising, still rising, reaching for the poor miserable people as they fled their homes, their hopes, their world in a desperate attempt to escape the rising waters.

Dan Randolph felt the straps of his safety harness cutting into his shoulders as he stared grimly out the window from his seat behind the two pilots. His head throbbed painfully and the filter plugs in his nostrils were hurting again. He barely noticed the copter's buffeting and jouncing in the choppy wind as he watched the swollen tide of refugees crawling sluggishly along the highway. It's like a war zone, Dan thought. Except that the enemy is Mother Nature. The flooding was bad enough, but the earthquake broke their backs.

Dan put the electronically boosted binoculars to his eyes once again, searching, scanning the miserable, soaking-wet throng below for one face, one individual, the one woman he had come to save. It was impossible. There must be half a million people down there, he thought. More. Finding her will take a miracle.

The chopper bounced and slewed wildly in a sudden gust of wind, banging the binoculars painfully against Dan's brow. He started to yell something to the pilot, then realized that they had run into another blustery squall. Fat, pounding raindrops splattered thickly against the copter's windows, cutting Dan's vision down almost to nothing.

The pilot slid back the transparent sanitary partition that isolated Dan's compartment. Dan suppressed an angry urge to slam it back. What good are sterile barriers if you open them to the outside air?

"We've got to turn back, sir," the pilot yelled over the thrumming thunder of the engines.

"No!" Dan shouted. "Not till we find her!"

Half turning in his seat to face Dan, the pilot jabbed a finger toward his spattered windscreen. "Mr. Randolph, you can fire me when we land, but I ain't going to fly through *that*."

Looking past the flapping windscreen wipers, Dan saw four deadly slim dark funnels writhing across the other side of the swollen Mississippi, dust and debris flying wherever they touched the ground. They looked like coiling, squirming snakes thrashing across the ground, smashing everything they touched: buildings exploding, trees uprooted, autos tossed into the air like dry leaves, homes shattered into splinters, RV parks, housing developments, shopping malls all destroyed at the flick of the twisters' pitiless, mindless malevolence, blasted as completely and ruthlessly as if they had been struck by an enemy missile attack.

The enemy is Mother Nature, Dan repeated silently, numbly, as he stared at the advancing tornadoes. There was nothing he could do about them and he knew it. They couldn't be bought, bribed, flattered, seduced, or threatened into obedience. For the first time since he'd been a child, Daniel Hamilton Randolph felt totally powerless.

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As he locked the partition shut again and fumbled in his pockets for his antiseptic spray, the chopper swung away, heading back toward what was left of the international airport. The Tennessee National Guard had thrown a cordon around the grounds; the airport was the Memphis region's last link with the rest of the country. The floods had knocked out electrical power, smashed bridges, covered roads with thick muddy brown water. Most of the city had been submerged for days.

Then came the earthquake. A solid nine on the Richter scale, so powerful that it flattened buildings from Nashville to Little Rock and as far north as St. Louis. New Orleans had already been underwater for years as the rising Gulf Of Mexico inexorably reclaimed its shoreline from Florida to Texas. The Mississippi was in flood all the way up to Cairo, and still rising.

Now, with communications out, millions homeless in the never-ending rains, aftershocks strong enough to tumble skyscrapers, Dan Randolph searched for the one person who meant something to him, the only woman he had ever loved.

He let the binoculars drop from his fingers and rested his head on the seatback. It was hopeless. Finding Jane out there among all those other people—

The copilot had twisted around in his seat and was tapping on the clear plastic partition.

"What?" Dan yelled.

Instead of trying to outshout the engines' roar through the partition, the copilot pointed to the earpiece of his helmet. Dan understood and picked up the headset they had given him from where he'd dumped it on the floor. He had sprayed it when they'd first handed it to him, but now he doused it again with the antiseptic.

As he clamped it over his head, he heard the metallic, static-streaked voice of a news reporter saying, ". . . definitely identified as Jane Scanwell. The former President was found, by a strange twist of fate, on President's Island, where she was apparently attempting to help a family of refugees escape the rising Mississippi waters. Their boat apparently capsized and was swept downstream, but snagged on treetops on the island.

"Jane Scanwell, the fifty-second President of the United States, died trying to save others from the ravages of flood and earthquake here in what remains of Memphis, Tennessee."

LA GUAIRA

It was raining in Venezuela, too, when Dan Randolph finally got back to his headquarters. Another hurricane was tearing through the Caribbean, lashing Barbados and the Windward Islands, dumping twenty-five centimeters of rain on the island of La Guaira and Caracas, on the mainland, with more to come.

Dan sat behind his big, bare desk, still wearing the rumpled slacks and pullover that he had travelled in from the States. His office smelled musty, mildewed from the incessant rain despite its laboring climate-control system. He wasn't wearing the protective nose plugs; the air in his office was routinely filtered and run past intense ultraviolet lamps.

Leaning back into the softly yielding caramel brown leather of his swivel chair, Dan gazed out at the windswept launch complex. The rockets had been towed back into the assembly buildings. In this storm they could not dare to launch even the sturdy, reliable Clipperships. The launch towers were visibly shaking in the gale-force wind, lashed by horizontal sheets of rain; roofs had already been peeled off some of the smaller buildings. Beyond the launch towers, the sea was a wild madhouse of frothing whitecapped waves. The wind howled like a beast of prey, rattling even the thick double-paned windows of Randolph's office.

Third storm to hit us and it's not even the Fourth of July yet. Business isn't

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lousy enough, we've got these double-damned hurricanes to deal with. At this rate I'll be broke by Labor Day.

We're losing, Dan thought. We're in a war and we're losing it. Hell, we've already lost it. What's the sense of pretending otherwise?

The dampness made him ache deep in his bones, an arthritic-like reminder of his age and the dose of radiation sickness he'd contracted years earlier. I ought to get back to Selene, he told himself. A man with a broken-down immune system shouldn't stay on Earth if he doesn't have to.

Yet for hours he simply sat there, staring out at the pounding storm, seeing only the face of Jane Scanwell, remembering the sound of her voice, the touch of her fingers, the soft silkiness of her skin, the scent of her, the way she brightened a room, they way she had filled his life even though they were never really together, not more than a few quick hours now and then before they fell into bitter argument. There was so much separating them. After she had left the White House, they had managed to spend a couple of days together on a tropical atoll. Even that had ended in a quarrel.

But for once they had seen things the same way, had the same goal, fought the same fight on the same side. The greenhouse cliff meant war, a war pitting humankind's global civilization against the blind forces of nature. Jane understood that as well as Dan did. They were going to fight this war together.

And it killed her.

Should I go on? Dan asked himself. What's the use of it? What's the sense of it? He wanted to cry, but the tears would not come.

Dan Randolph had always seemed larger than his actual physical size. He was a solidly-built welterweight, still in trim physical shape, although now, in his sixties, it took grueling hours in the gym to maintain his condition. His once-sandy hair was almost completely gray now; his staff people called him "the Silver Fox" behind his back. He had a fighter's face, with a strong stubborn jaw and a nose that had been flattened years ago by a fist, when he'd been a construction worker in space. Despite all the wealth he'd amassed since those early days, he'd never had his nose fixed. Some said it was a perverse sense of machismo. His light gray eyes, which had often glinted in amusement at the foolishness of men, were bleak and saddened now.

A chime sounded, and the sleek display screen of his computer rose slowly, silently out of the desktop surface.

Dan swiveled his chair to see the screen. His administrative assistant's young, somber face looked out at him. Teresa was a native of Caracas, tall, leggy, cocoa-cream complexion, deep brown almond eyes and thick lustrous midnight dark hair. Years earlier Dan would have tried to bed her and probably succeeded. Now he was simply annoyed at her intrusion into his memories.

"It's almost dinnertime," she said.

"So what?"

"Martin Humphries has been waiting all day to see you. He's the man Zack Freiberg wants you to meet."

Dan grimaced. Zack had been the first one to warn Dan of the impending greenhouse cliff.

"Not today, Teresa," he said. "I don't want to see anybody today."

The young woman hesitated a heartbeat, then asked, hesitantly, almost timidly, "Do you want me to bring you a dinner tray?"

Dan shook his head. "I'm not hungry."

"You have to eat."

He looked at her image on his screen, so intent, so young and concerned and worried that the boss was going off the deep end. And he felt anger rising inside him, unreasoning blind blazing rage.

"No, goddammit to hell and back," he snapped. "*You* have to eat. I can do any goddamned thing I want to, and if you

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want to keep drawing your paycheck you'd better leave me the hell alone."

Her eyes went wide. Her mouth opened, but she said nothing. Dan snapped his fingers and the screen went blank. Another snap and it folded back into its niche in the desk's gleaming rosewood top.

Leaning back in his chair, Dan closed his eyes. He tried to close his mind against the memories, but that was impossible.

It was all going to be so damned great. OK, a century or two of global warming would lead to a greenhouse cliff. Not a gradual warm-up but a sudden, abrupt change in the world's climate. All that latent heat stored in the oceans would pour into the atmosphere. Ice caps in Greenland and Antarctica melting away. Sea levels shoot up over a decade or two. Big storms and lots of them. Climate shifts turning croplands into deserts.

So what? We'll use the resources of space to solve all those problems. Energy? We'll build solar power satellites, beam energy from space to wherever it's needed. Raw materials? We'll mine the Moon and the asteroids; there's more natural resources in space than the whole Earth can provide. Food production?

Well, that would be a tough one. We all knew that. But with enough energy and enough raw materials we could irrigate the croplands that were being desiccated by the climate shift.

Yeah, sure. And when half the world's major cities got flooded out, what did we do? What could we do? When the electrical power grid got shattered, what did we do? When earthquakes and tsunamis wiped out the heart of Japan's industrial capacity, what did we do? Diddley-squat. When this quake flattened the Midwest, what did we do? We tried to help the survivors and Jane got herself killed in the attempt.

The office door banged open and a huge, red-bearded man pushed in, carrying an ornately-carved teak tray laden with steaming dishes. In his massive hands the tray looked like a miniature child's toy.

"Teresa says you've got to eat," he announced in a high, sweet tenor as he set the tray on Dan's desk.

"I told her I'm not hungry."

"You can't fookin' starve yourself. Eat something."

Dan glanced at the tray. A steaming bowl of soup, a salad, a main course hidden under a stainless steel dome, a carafe of coffee. No wine. Nothing alcoholic.

He pushed the tray toward the red-haired giant. "You eat it, George."

Pulling one of the upholstered chairs up close to the desk, Big George looked his boss in the eye and pushed the tray back toward Randolph.

"Eat," he said. "It's good for ya."

Dan stared back at George Ambrose. He'd known Big George since he'd been a fugitive on the Moon, hiding out from the Selene City authorities with a handful of other free souls who styled themselves the Lunar Underground. Big George was Dan's personal bodyguard now; he wore custom-tailored suits instead of patched coveralls. But he still looked like a barely-tamed frontiersman, big, shaggy, the kind of man who could gleefully pound your head down into your ribcage with no personal malice at all.

"Tell you what," Dan said, feeling a reluctant smile bend his lips a little. "I'll split it with you."

George grinned back at him. "Good thinking, boss."

They ate in silence for several minutes, George gobbling the entire main course, which turned out to be a thick slab of prime rib. Dan took a few spoonfuls of soup and nibbled at the salad.

"Better than the old days, huh?" George said, still chewing prime rib. "Fookin' soyburgers and recycled piss for water."

Dan ignored the younger man's at-

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tempt to jolly him. "Has Teresa gone home?" he asked.

"Nope."

Nettled, Dan glanced at his wristwatch. "She's not my nursemaid, double-damn it. I don't want her hovering over me like—"

"That Humphries bloke is still waitin' to see you," George said.

"Now? He's out there now? It's almost nine o'clock, for chrissakes. What's wrong with him? Is he stuck here because of the storm? Doesn't Teresa have the smarts to put him up in one of the guest suites?"

George shook his shaggy head. "He said he'll wait until you're ready to see 'im. He did have an appointment, y'-know."

Dan let his breath out in a weary sigh. I just got back from the funeral and they expect me to stick to a schedule made out weeks ago.

"Teresa says he's makin' her nervous."

"Nervous?"

"He's comin' on to her. I can see it meself."

Frowning, Dan muttered, "Teresa can take care of herself."

"The voice of experience?" George grinned.

"He's been hitting on her all the time he's been waiting for me?"

"Want me to shoo 'im off?" George asked.

For a moment Dan relished the image of George hustling his visitor out of the building. But then he realized that the man would simply come back tomorrow. I'll have to get back to business, he told himself. Can't avoid it forever.

"Take the tray out," he said to Big George, "and show this Humphries guy in."

George smacked his lips. "I can bring in dessert and coffee."

"Fine," Dan said, unwilling to argue. "Do that."

Grinning, George scooped up the crumb-littered tray in one hand and started for the door. Dan saw that the desktop was sprinkled with crumbs, too. Annoyed, he brushed them to the carpet.

Teresa appeared at the door. "Mr. Martin Humphries," she announced. She looked tense, Dan thought. Humphries must have really rattled her.

Martin Humphries looked quite young. He was on the small side, a couple of centimeters shorter than Teresa, and he seemed soft, with rounded shoulders and a waistline that was already getting thick, despite the careful drape of his burgundy blazer. He seemed to radiate energy, though, as he strode confidently across the office toward Dan's desk.

Dan got to his feet and extended his hand across the desk.

"Sorry to keep you waiting," he said, making himself smile.

Humphries took Dan's hand in a firm grip. "I understand," he replied. "I'm sorry to intrude on your grief."

His eyes told Dan that the words were nothing more than an expected ritual. Martin Humphries' face was round, almost boyish. But his eyes were diamond-hard, cold and gray as the storm-lashed sea outside the window.

As they sat down, George re-entered the office bearing a tray of pastries and the same carafe of coffee, with a pair of china cups and saucers alongside it. For all his size, Big George walked with the lightfooted step of a dancer—or a cat burglar. Neither Dan nor Humphries said a word as George deftly deposited the tray on the desk and swiftly, silently left the office.

"I hope I haven't kept you from your dinner," Dan said, gesturing to the pastries.

Humphries ignored the tray. "No problem. I enjoyed chatting with your secretary."

"Did you?" Dan said thinly.

"She's quite a piece of work. I'd like to hire her away from you."

"Not a chance," Dan snapped.

With a careless shrug, Humphries

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said, "That's not important. I came here to talk to you about the current situation."

Dan waved toward the window. "You mean the greenhouse cliff?"

"I mean the way we can help the global economy to recover from the staggering losses it's sustained—and make ourselves a potful of profits while we're doing it."

Dan felt his brows hike up. He reached for one of the delicate little pastries, then decided to pour himself a cup of coffee first. Dan's firm, Astro Manufacturing Inc., was close to bankruptcy and the whole financial community knew it.

"I could use a potful of profits," he said carefully.

Humphries smiled, but Dan saw no warmth in it.

"What do you have in mind?" he asked.

"The Earth is in chaos because of this sudden climate shift," said Humphries.

"The greenhouse cliff, yes," Dan agreed.

"Selene and the other lunar communities are doing rather well, though."

Dan nodded. "On the Moon there's no shortage of energy or raw materials. They've got everything they need. They're pretty much self-sufficient now."

"They could be helping the Earth," said Humphries. "Building solar power satellites. Sending raw materials to Earth. Even manufacturing products that people down here need but can't get because their own factories have been destroyed."

"We've tried to do that," Dan said. "We're trying it now. It's not enough."

Humphries nodded. "That's because you've been limiting yourself to the resources you can obtain from the Moon."

"And the NEAs," Dan added.

"The near-Earth asteroids, yes." Humphries nodded as if he'd expected that response.

"So what are you suggesting?"

Humphries glanced over his shoulder, as if afraid that someone might be eavesdropping. "The Belt," he said, almost in a whisper.

Dan looked at Humphries for a long, silent moment. Then he leaned his head back and laughed, long and loud and bitterly.

SPACE STATION *GALILEO*

They were gaining on her.

Still wearing the spacesuit, Pancho Lane zipped weightlessly through the lab module, startling the Japanese technicians as she propelled herself headlong down its central aisle with a flick of her strong hands against the lab equipment every few meters. Behind her she could hear the men yelling angrily.

If any of those dip-brains have the smarts to suit up and go EVA to head me off, she thought, I'm toast.

It had started out as a game, a challenge. Which of the pilots aboard the station could breathe vacuum the longest? There were six Astro Corporation rocket jockeys waiting for transport back to Selene City: four guys, Pancho herself, and the new girl, Amanda Cunningham.

Pancho had egged them on, of course. That was part of the sting. They'd all been hanging around the galley, literally floating when they didn't anchor themselves down with the footloops fastened to the floor around the table and its single pipestem-slim leg. The conversation had gotten around to vacuum breathing: how long can you hold your breath in space without damaging yourself?

"The record is four minutes," one of the guys had claimed. "Harry Kirschbaum."

"Harry Kirschbaum? Who the hell is he? I never heard of him."

"He died young."

They all had laughed.

Amanda, who had just joined the team fresh from tech school in London, had the face of an angelic schoolgirl

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with soft curly blonde hair and big innocent blue eyes; but her curvaceous figure had all the men panting. She said, "I had to readjust my helmet once, during a school exercise in the vacuum tank."

"How long did that take?"

She shrugged, and even Pancho noticed the way it made her coveralls jiggle. "Ten seconds, perhaps. Fifteen."

Pancho didn't like Amanda. She was a little tease who affected an upperclass British accent. One look at her and the men forgot about Pancho, which was a shame because a couple of the guys were really nice.

Pancho was lean and stringy, with the long slim legs of her African heritage. Her skin was no darker than a good tan would produce back in west Texas, but her face was just plain ordinary, with what she considered a lantern jaw and squinty little commonplace brown eyes. She always kept her hair cut so short that the rumor had gone around that she was a lesbian. Not true. But she had a man's strength in her long, muscled arms and legs, and she never let a man beat her in anything—unless she wanted to.

The transfer buggy that was slated to take them all back to Selene was running late. Cracked nozzle on one of the thrusters and the last thing the flight controllers wanted was a derelict transfer vehicle carrying six rocket jocks; they would be rebuilding the buggy forty-five ways from Sunday while they coasted Moonward.

So the six of them waited in the galley and talked about vacuum breathing. One of the guys claimed he'd sucked vacuum for a full minute.

"That explains your I.Q.," said his buddy.

"Nobody's made it for a full minute."

"Sixty seconds," the man maintained stubbornly.

"Your lungs would explode."

"I'm telling you, sixty seconds. On the dot."

"No damage?"

He hesitated, suddenly shamefaced.

"Well?"

With an attempt at a careless shrug, he admitted, "Left lung collapsed."

They snickered at him.

"I could prob'ly do it for sixty seconds," Pancho announced.

"You?" The man nearest her guffawed. "Now, Mandy here, she's got the lung capacity for it."

Amanda smiled shyly. But when she inhaled they all noticed it.

Pancho hid her anger at their ape-man attitude. "Ninety seconds," she said calmly.

"Ninety seconds? Impossible!"

"You willin' to bet on that?" Pancho asked.

"Nobody can stand vacuum for ninety seconds. It'd blow your eyeballs out."

Pancho smiled toothily. "How much money are you ready to put against it?"

"How can we collect off you after you're dead?"

"Or brain-damaged."

"She's already brain-damaged if she thinks she can suck vacuum for ninety seconds."

"I'll put my money in an escrow account for the five of you to withdraw in case of my death or incapacitation," Pancho said calmly.

"Yeah, sure."

Pointing to the phone on the wall, next to the sandwich dispenser, she said, "Electronic funds transfer. Takes all of two minutes to set up."

They fell silent.

"How much?" Pancho said, watching their eyes.

"A week's pay," snapped one of the men.

"A month's pay," Pancho said.

"A whole month?"

"Why not? You're so freakin' sure I can't do it, why not bet a month's pay? I'll put five months worth of mine in the escrow account, so you'll each be covered."

"A month's pay."

In the end they had agreed to it. Pan-

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cho knew that they figured she'd chicken out after twenty-thirty seconds and they'd have her money without her killing herself.

She figured otherwise.

So she used the galley phone to call her bank in Lubbock. A few taps on the phone's touchtone keypad and she had set up a new account and dumped five months' pay into it. All five of the other jocks watched the phone's tiny screen to make certain Pancho wasn't playing any tricks.

Then each of them in turn called their banks and deposited a month's pay into Pancho's new account. Pancho listened to the singsong of the phone's tones as she laid her plans for the coming challenge.

Pancho suggested they use the airlock down at the far end of the maintenance module. "We don't want some science geek poppin' in on us and gettin' so torqued he punches the safety alarm," she said.

They all agreed easily. So they floated through two lab modules and the shabby-looking habitat module where the long-term researchers were housed and finally made it to the cavernous maintenance unit. There, by the airlock, Pancho chose a spacesuit from the half-dozen standard models lined up against the bulkhead, size large because of her height. She quickly wriggled into it. They even helped her put on the boots and check out the suit's systems.

Pancho pulled the helmet over her head and clicked the neck seal shut.

"OK," she said, through the helmet's open visor. "Who's gonna time me?"

"I will," said one of the guys, raising his forearm to show an elaborate digital wristwatch.

"You go in the lock," said the man beside him, "pump it down and open the outside hatch."

"And you watch me through the port," Pancho said, tapping the thick round window on the airlock's inner hatch with gloved knuckles.

"Check. When I say go, you open your visor."

"And I'll time you," said the guy with the fancy wristwatch.

Pancho nodded inside the helmet.

Amanda looked concerned. "Are you absolutely certain that you want to go through with this? You could kill yourself, Pancho."

"She can't back out now!"

"Not unless she wants to forfeit five months' pay."

"But seriously," Amanda said. "I'm willing to call off the bet. After all—"

Pancho reached out and tousled her curly blonde hair. "Don't sweat it, Mandy."

With that, she stepped through the open airlock hatch and slid down her visor. She waved to them as they swung the hatch shut. She heard the pump start to clatter; the sound quickly dwindled as the air was sucked out of the metal-walled chamber. When the telltale light by the inner hatch turned red, Pancho touched the button that slid the outer hatch open.

For a moment she forgot what she was up to as she drank in the overwhelming beauty of the Earth spread out before her dazzled eyes. Brilliantly bright, intensely blue oceans and enormous sweeps of clouds so white it almost hurt to look upon them. It was glorious, an overwhelming panorama that never failed to make her heart beat faster.

You've got work to do, girl, she reminded herself sternly.

Turning to the inner hatch, she could see all five of their faces clustered around the little circular port. None of them had the sense to find a radio, Pancho knew, so she gestured to her sealed helmet visor with a gloved finger. They all nodded vigorously and the guy with the fancy wristwatch held it up where Pancho could see it.

The others backed away from the port while the guy stared hard at his wristwatch. He held up four fingers,

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then three . . .

Counting down, Pancho understood.

. . . two, one. He jabbed a finger like a make-believe pistol at Pancho, the signal that she was to lift her visor *now*.

Instead, Pancho launched herself out the airlock, into empty space.

LA GUAIRA

Martin Humphries looked irked. "What's so funny about the Asteroid Belt?"

Dan shook his head. "Not funny, really. Just . . . I didn't expect that from you. You've got a reputation for being a hard-headed businessman."

"I'd like to believe that I am," Humphries said.

"Then forget about the Belt," Dan snapped. "Been there, done that. It's too far away. The costs would outweigh the profits by a ton."

"It's been done," Humphries insisted.

"Once," said Dan. "By that nutcase Gunn. And he damned near got himself killed doing it."

"But that one asteroid was worth close to a trillion dollars once he got it into lunar orbit."

"Yeah, and the double-damned GEC took control of it and bankrupted Gunn."

"That won't happen this time."

"Why not? You don't think the GEC would seize any resources we bring to Earth? That's the reason the Global Economic Council was created—to control the whole twirling Earth's international trade."

Humphries smiled coldly. "I can handle the GEC. Trust me on that one."

Dan stared at the younger man for a long, hard moment. Finally he shook his head and replied, "It doesn't matter. I'd even be willing to let the GEC run the show."

"You would?"

"Hell yes. We're in a global emergency now. Somebody has to allocate resources, control prices, see to it that nobody takes advantage of this crisis to line his own pockets."

"I suppose so," Humphries said slowly. "Still, I'm convinced there's a lot of money to be made by mining the Belt."

Nodding, Dan agreed, "There are a lot of resources out there, that's for sure. Heavy metals, organics, resources we can't get from the Moon."

"Resources that the Earth needs, and the GEC would be willing to pay for."

"Mining the asteroids," Dan mused. "That's a major undertaking. A *major* undertaking."

"That's why I'm here. Astro Manufacturing has the resources to do it."

"Astro Manufacturing is just about broke and you know it."

"I wasn't talking about financial resources," Humphries said, waving a hand in the air almost carelessly.

"Oh no?"

"No." Pointing a finger toward the window and the storm-battered launch facility outside, Humphries said, "You've got the technological know-how, the teams of trained personnel, the rockets and infrastructure to get us into space."

"And it's bleeding me white because there's less and less of a market for launch services. Nobody can afford to buy electronics manufactured on the Moon, not when they're being driven from their homes by floods and earthquakes."

Humphries' brows rose questioningly.

"I know, I know," Dan said. "There's the energy market. Sure. But how many solar power satellites can we park in orbit? The double-damned GEC just put a cap on them. We're building the next to last one now. After those two, no more powersats."

Before Humphries could ask why, Dan continued, "The goddamned Greater Asia Power Consortium complained about the powersats undercutting their prices. And the double-damned Europeans sided with them. Serve 'em all right if they freeze their asses off when the Gulf Stream breaks up."

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"The Gulf Stream?" Humphries looked startled.

Dan nodded unhappily. "That's one of the projections. The greenhouse warming is already changing ocean currents. When the Gulf Stream breaks up, Europe goes into the deep freeze; England's weather will be the same as Labrador's."

"When? How soon?"

"Twenty years, maybe. Maybe a hundred. Ask five different scientists and you get twelve different answers."

"That's a real opportunity," Humphries mused. "Winterizing all of Europe. Think of it! What an opportunity!"

"Funny," Dan retorted. "I was thinking of it as a disaster."

"You see the glass half empty. To me, it's half full."

Dan had a sudden urge to throw this young opportunist out of his office. Instead, he slumped back in his chair and muttered, "It's like a sick Greek tragedy. Global warming is going to put Europe in the deep-freezer. Talk about ironic."

"We were talking about the energy market," Humphries said, regaining his composure. "What about the lunar helium-three?"

Dan wondered if his visitor was merely trying to pump him. Warily, he answered, "Barely holding its own. There's not that many fusion powerplants up and running yet—thanks to the kneejerk anti-nuke idiots. And digging helium-three out of the lunar regolith ain't cheap. Fifty parts per million sounds good to a chemist, maybe, but it doesn't lead to a high profit ratio, let me tell you."

"So you'd need an injection of capital to start mining the asteroids," Humphries said.

"A transfusion," Dan grumbled.

"That can be done."

Dan felt his brows hike up. "Really?"

"I can provide the capital," Humphries said, matter-of-factly.

"We're talking forty-fifty billion, at least."

Humphries waved a hand, as if brushing away an annoyance. "You wouldn't need that much for a demonstration flight."

"Even a one-shot demo flight would cost a couple bill," Dan said.

"Probably."

"Where are you going to get that kind of money? Nobody's willing to talk to me about investing in Astro."

"There are people who'd be willing to invest that kind of money in developing the asteroid market."

For an instant Dan felt a surge of hope. It could work! Open up the Asteroid Belt. Bring those resources to Earth's needy people. Then the cost figures flashed into his mind again, as implacable as Newton's laws of motion.

"You know," he said wearily, "if we could just cover our own costs I'd be willing to try it."

Humphries looked disappointed. "Just cover your own costs?"

"Damned right. People need those resources. If we could get them without driving ourselves into bankruptcy, I'd go to double-damned Pluto if I had to!"

Relaxing visibly, Humphries said, "I know how we can do it and make a healthy profit, besides."

Despite himself, Dan felt intrigued. "How?"

"Fusion rockets."

By the seven cities of Cibola, Dan thought, this guy's a fanatic. Worse: he's an enthusiast.

"Nobody's made a fusion rocket," he said to Humphries. "Fusion power generators are too big and heavy for flight applications. Everybody knows that."

With the grin of a cat that had just finished dining on several canaries, Humphries replied, "Everybody's wrong."

Dan thought it over for all of half a second, then leaned both his hands on his desktop, palms down, and said, "Prove it to me."

Without a word, Humphries fished a data chip from his jacket pocket and

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handed it to Dan.

SPACE STATION *GALILEO*

Leaving her five fellow astronauts gaping dumbfounded at the airlock in the maintenance module, Pancho sailed weightlessly to the metal arm of the robotic cargo handling crane jutting out from the space station. It was idle at the moment; with no mass of payload to steady it, the long, slim arm flexed noticeably as Pancho grasped it in both hands and swung like an acrobat up to the handgrips that studded the module's outer skin.

Wondering if the others had caught on to her sting, Pancho hand-walked along the module's hull, clambering monkeylike from one runglike grip to the next. To someone watching from beyond the space station it would have looked as if she were scampering along upside down, but to Pancho it seemed as if the space station was over her head and she was swinging like a kid in a zero-gee jungle gym.

She laughed inside her helmet as she reached the end of the maintenance module and pushed easily across the connector section that linked to the habitation module.

"Hey Pancho, what the hell are you doing out there?"

They had finally gotten to a radio, she realized. But as long as they were puzzled, she was okay.

"I'm taking a walk," she said, a little breathlessly from all the exertion.

"What about our bet?" one of the men asked.

"I'll be back in a few minutes," she lied. "Just hang tight."

"What are you up to, Pancho?" asked Amanda, her voice tinged with suspicion.

Pancho fell back on her childhood answer. "Nothin'."

The radio went silent. Pancho reached the airlock at the end of the hab module and tapped out the standard code. The outer hatch slid open. She ducked inside, sealed the hatch and didn't bother to wait for the lock to fill with air. She simply pushed open the inner hatch and quickly sealed it again. A safety alarm shrilled automatically but cut off when the module's air pressure equilibrated again. Yanking off the spacesuit's cumbersome gloves, Pancho slid her visor up as she went to the wallphone by the airlock hatch.

Blessed with perfect pitch and a steel-trap memory, Pancho punched out the numbers for each of the five astronauts' banks in turn, followed by their personal identification codes. Mother always said I should have been a musician, Pancho mused as she transferred almost the total amount of each account into her own bank account. She left exactly one international dollar for each of them, so the bank's computers would not start the complex process of closing down their accounts.

By the time she finished, the hatch at the other end of the habitation module swung open and her five fellow astronauts began to push through, one at a time.

"What's going on?" demanded the first guy through.

"Nothin'," Pancho said again. Then she dived through the hatch at her end of the long narrow module.

Into the Japanese lab module she swam, flicking her fingers along the equipment racks lining both sides of its central aisle, startling the technicians working there. Laughing to herself, she wondered how long it would take them to figure out that she had looted their bank accounts.

It didn't take very long. By the time Pancho had reached the galley once again, they were roaring after her, the men bellowing with outrage.

"When I get my hands on you, I'm gonna break every bone in your scrawny body!" was one of their gentler threats.

Even Amanda was so furious she lapsed back to her native working-class accent: "We'll 'ang you up by your

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bloody thumbs, we will!"

As long as I can stay ahead of them, I'm OK, Pancho told herself as she skimmed through the European lab module and into the observatory section, ducking under and around the bulky telescopes and electronics consoles there. They were still yelling behind her, but she wondered if all five of them were still chasing. By now there'd been plenty of time for one or more of them to pop into a suit and cut across the top of the T-shaped station to cut her off.

Sure enough, when she barged into the Russian hab module, two of the guys were standing at the far end in spacesuits, visors up, waiting for her like a pair of armored cops.

Pancho glided to a halt. One of the privacy unit screens slid back and a stubbled, bleary, puffy male face peered out, then quickly popped back in again and slid the screen shut with a muttered string of what sounded like Slavic cursing.

The other three—Amanda and two of the men—came through the hatch behind her. Pancho was well and truly trapped.

"What the fuck are you trying to pull off, Pancho?"

"You cleaned out our bank accounts!"

"We oughta string you up, damn you!"

She smiled and spread her hands placatingly. "Now fellas, you can't hang a person in microgee. You know that."

"This isn't funny," Amanda snapped, back to her faux Oxford enunciation.

"I'll make restitution, OK?" Pancho offered.

"You damned well better!"

"And you lost the bet, too, so we each get a month's pay from you."

"No," Pancho said as reasonably as she could. "We never went through on the vacuum breathing, so the bet's off."

"Then we want our money back from your goddamned escrow account!"

"Sure. Fine."

Amanda pointed to the wallphone by the hatch. "You mentioned restitution," she said.

Meekly, Pancho floated to the phone and tapped out her number. "You'll have to give me your account numbers," she said. "So I can put the money back in for you."

"We'll punch in the account numbers ourselves," Amanda said firmly.

"You don't trust me?" Pancho managed to keep a straight face, but just barely.

They all growled at her.

"But it was only a joke," she protested. "I had no intention of keeping your money."

"Not much you didn't," one of the guys snapped. "Good thing Mandy figured out what you were up to."

Pancho nodded in Amanda's direction. "You're the brightest one around, Mandy," she said, as if she believed it.

"Never mind that," Amanda replied tartly. To the men she said, "Now we'll all have to change our ID codes, since she's obviously figured them out."

"I'm going to change my account number," said one of the guys.

"I'm gonna change my *bank*," another said fervently.

Pancho sighed and tried her best to look glum, chastised. Inwardly, she was quivering with silent laughter. What a hoot! And none of these bozos realizes that the half hour or so they've spent chasing me means half an hour's worth of interest from each of their accounts into mine. It's not all that much, but every little bit helps.

She just hoped they wouldn't figure it out while they were all cooped up in the transfer buggy on the way to the Moon.

Well, she thought, if they try to get physical I'll just have to introduce them to Elly.

CHENGDU, SICHUAN PROVINCE

Dan had to shout through his sanitary mask to make himself heard over the din

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of construction.

"All I'm asking, Zack, is can he do it or can't he?"

He'd known Zack Freiberg for more than twenty years, since Zack had been an earnest young planetary geochemist intent on exploring asteroids and Dan had hired him away from his university post. Freiberg had taken flak from his friends in academia for joining big, bad Dan Randolph, the greedy capitalist founder and head of Astro Manufacturing. But over the years a mutual respect had slowly developed into a trusting friendship. It had been Zack who'd first warned Dan about the looming greenhouse cliff, and what it would do to the Earth's climate.

The greenhouse cliff had arrived, and the Earth's politicians and business leaders had sailed blindly over its edge as the planet plunged into catastrophic warming. Zack was no longer the chubby, apple-cheeked kid Dan had first met. His strawberry hair had gone iron gray, although it was still thick and tightly curled. The past few years had toughened him, made him leaner, harder, boiled away the baby fat in his body. His face had hardened, too, as he watched his equations and graphs turn into massive human suffering.

The two men were standing on the edge of a denuded ridge, looking out across a barren coal-black valley where thousands of Chinese workers toiled unceasingly. By all the gods, Dan thought, they really do look like an army of ants scurrying around. In the middle of the valley four enormously tall smokestacks of a huge electricity-generating plant belched dark-gray fumes into the hazy sky. Mountainous piles of coal lay by the railroad track that ran alongside the power plant. Off on the horizon, beyond the farther stripped-bare ridge, the Yangzi River glittered in the hazy morning sunshine like a deadly boa constrictor slowly creeping up on its prey. A sluggish warm breeze smelled of raw coal and diesel fumes.

Dan shuddered inwardly, wondering how many billions of microbes were worming their way through his sanitary mask and nose plugs, eager to chew past his weakened immune system and set up homes for themselves inside his body.

"Dan, I really don't have time for this," Freiberg hollered over the roar of a huge truck carrying twenty tons of dirt and rubble down into the valley on wheels that dwarfed both men.

"I just need a few hours of your time," Dan said, feeling his throat going hoarse from his shouting. "Jeez, I came all the way out here to get your opinion on this."

It was a sign of the Chinese government's belated realization that the greenhouse warming would decimate China as well as the rest of the world that they had asked Freiberg to personally direct their massive construction program. At one end of the valley, Chinese engineers and laborers were building a dam to protect the electrical power-generating station from the encroaching Yangzi. At the other end, a crew from Yamagata Industries was constructing a complex pumping station to remove the carbon dioxide emitted by the power station's stacks and store it deep underground, in the played-out seams of the coal bed that provided fuel for the generators.

With an exasperated frown, Freiberg said, "Listen, I know I still get my paycheck from Astro, but that doesn't mean I can jump whenever you blow the whistle."

Dan looked into the other man's light blue eyes and saw pain there, disappointment and outright fear. Zack blames himself for this catastrophe, Dan knew. He discovered the greenhouse cliff and he acts as if it's all his fault. Instead of some fathead king shooting the messenger, the messenger wants to shoot himself.

"Look, Zack," he said, as reasonably as he could manage, "you have to eat a meal now and then, don't you?"

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Freiberg nodded warily. He'd been sweet-talked by Dan into doing things he hadn't wanted to do often enough in the past.

"So I brought you lunch," Dan said, waving his arm in the direction of the oversized mobile home he'd arrived in. Its roof glittered with solar panels. "When the noon whistle blows, come in and break some bread with me. That's all I'm asking."

"You want me to look at this proposal over lunch? You think I can make a technical decision about this in an hour or less?"

Dan shrugged disarmingly. "If you can't, you can't. All I'm asking is that you give it a look."

Freiberg gave Dan a look that was far from happy.

Yet five minutes after noon, he climbed up through the open door of Dan's big mobile home.

"I might have known," he muttered as he stepped past Big George, standing by the doorway.

The van was luxuriously fitted out. George was Dan's major domo and bodyguard. An attractive young Japanese woman, petite and silent, was stirring steaming vegetables in an electric wok. Dan was sitting in the faux-leather couch that curved around the fold-down dinner table, a suede jacket draped over his shoulders even though the van felt uncomfortably warm to Freiberg. Zack could see the crease across Dan's face that the sanitary mask had left. "Drink?" Dan asked, without getting to his feet. A half-empty tumbler of something bubbly sat on the table before him.

"What are you having?" Freiberg asked, sliding into the couch where it angled around the table's end. The table was already set for two.

"Ginger beer," said Dan. "George turned me on to it. Nonalcoholic and it's even good for the digestion."

Freiberg shrugged his rounded shoulders. "OK, I'll have the same."

George quickly pulled a brown bottle from the refrigerator, opened it, and poured Freiberg a glass of ginger beer.

"Goes good with brandy, y'know," he said as he handed the glass to Freiberg.

The scientist accepted the glass wordlessly and George went back to his post by the door, folding his heavy arms over his massive chest like a professional bouncer.

After a sip of his drink, Dan asked, "Might have known what?"

Freiberg waved a hand around the compartment. "That you'd be living in the lap of luxury, even out here."

Dan laughed. "If you've got to go out into the wilderness, you might as well bring a few creature comforts with you."

"Kind of warm in here, though," Freiberg complained mildly.

Dan smiled gauntly at him. "You're accustomed to living in the wild, Zack. I'm not."

"Yeah, guess so." Freiberg glanced at the painting above Dan's head: a little girl standing by a banyan tree. "Is that real?"

"Holoprint," said Dan. "A Vickrey."

"Nice."

"What're you living in, out here?"

"A tent," said Freiberg.

Nodding, Dan said, "That's what I thought."

"It's a pretty good tent, as tents go, but it's nothing like this." His eyes swept the dining area appreciatively. "How many other rooms in here?"

"Just two: office and bedroom. King-sized bed, of course."

"Of course."

"You like it, it's yours."

"The holoprint?"

"The van. The whole shebang. I'll be leaving later this afternoon. If you can find somebody to drive George and me to the airstrip you can keep this for yourself."

Surprised, Freiberg blurted, "Can you afford to give it away? From what I've heard—"

"For you, Zack," Dan interrupted,

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"my last penny. If it comes to that."

Freiberg made a wry face. "You're trying to bribe me."

"Yep. Why not?"

With a resigned sigh, the scientist said, "All right, let me see this proposal you want me to look at."

"Hey George," Dan called, "bring me the notebook, will you?"

Almost an hour later, Freiberg looked up from the notebook's screen and said, "Well, I'm no rocket engineer, and what I know about fusion reactors you could put into a thimble, but I can't find anything obviously wrong with this."

"Do you think it'll work?" Dan asked earnestly.

"How the hell should I know?" Freiberg snapped irritably. "Why in hell did you come all the way out here to ask my opinion on something you *know* is outside my expertise?"

Dan hesitated for several heartbeats, then answered, "Because I can trust you, Zack. This guy Humphries is too slick for me to believe. All the experts I've contacted claim that this fusion rocket is workable, but how do I know that he hasn't bought them off? He's got something up his sleeve, some hidden agenda, and this fusion rocket idea is just the tip of the iceberg. I think he wants to get his paws on Astro."

"That's a helluva mixture of metaphors," Freiberg said, grinning despite himself.

"Never mind the syntax. I don't trust Humphries. I do trust you."

"Dan, my opinion doesn't mean a damned thing here. You might as well ask George, or your cook."

Hunching forward over the table, Dan said, "You can talk the talk, Zack. You can contact the experts that Humphries has used and sound them out. You can talk to other people, the real specialists in these areas, and see what they think. They'd talk to you, Zack, and you'd understand what they're saying. You can—"

"Dan," Freiberg said icily, "I'm working twenty-six hours a day already."

"I know," Dan said. "I know."

Freiberg had thrown himself totally into the global effort to cut down on the greenhouse gas emissions given off by the world's fossil-fueled power-generating stations, factories, and vehicles.

Faced with disastrous shifts in climate due to the greenhouse warming, the nations of the world were belatedly, begrudgingly, attempting to remedy the cataclysm. Led by the Global Economic Council, manufacturers around the world were desperately trying to convert automobiles and other vehicles to electrical motors. But that meant trebling the global electricity-generating capacity, and fossil-fueled power plants were faster and cheaper to build than nuclear plants. There was still plenty of petroleum available, and the world's resources of coal dwarfed the petroleum reserves. Fission-based power plants were still anathema because of the public's fear of nuclear power. The new fusion generators were costly, complex, and also hindered by stubborn public resistance to anything nuclear.

So more and more fossil-fueled power plants were being built, especially in such rising industrial nations as China and South Africa. The GEC insisted that new plants sequester their carbon dioxide emissions, capture the dangerous greenhouse gas, and safely pump it deep underground.

Zachary Freiberg had devoted his life to the effort to mitigate the greenhouse disaster. He had taken an indefinite leave of absence from his position as chief scientist of Astro Manufacturing and crisscrossed the world, directing massive construction projects. His wife had left him, he had not seen his children in more than a year, and his personal life was in tatters, but he was driven to do what he could, what he had to do, to help slow the greenhouse warming.

"So how's it going?" Dan asked him.

Freiberg shook his head. "We're shovelling shit against the tide. There's just no way we can reduce greenhouse emis-

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sions enough to make a difference."

"But I thought—"

"We've been working our butts off for . . . how long has it been? Ten years? Not even a dent. When we started, fossil fuel burning pumped six billion tons of carbon dioxide into the air every year. Know how much we're putting out now?"

Dan shook his head.

"Five point three billion tons," Freiberg said, almost angrily.

Dan grunted.

Pointing through the van's window to the massive trucks rumbling by, Freiberg grumbled, "Yamagata's trying to convert their whole fleet of trucks to electricity, but the Chinese are still using diesels. Some people just don't give a damn! The Russians are starting to talk about cultivating what they call the 'virgin lands' in Siberia, where the permafrost is melting. They think they can turn the region into a new grain belt, like the Ukraine."

"So something good might come out of all this," Dan murmured.

"My ass," Freiberg snapped. "The oceans are still warming up, Dan. The clathrates are going to break down if we can't stop the ocean temperature rise. Once they start releasing the methane that's frozen in them . . ."

Dan opened his mouth to reply, but Freiberg kept right on agonizing. "You know how much methane is locked up in the clathrates? Two times ten to the sixteenth tons. Twenty quadrillion tons! Enough to produce a greenhouse that'll melt all the ice in Greenland *and* Antarctica. Every glacier in the world. We'll all drown."

"All the more reason," Dan said, "for pushing out to the Asteroid Belt. We can bring in all the metals and minerals the Earth needs, Zack! We can move the world's industrial operations into space, where they won't screw up the Earth's environment."

Freiberg gave Dan a disbelieving look.

"We can do it!" Dan insisted. "If this fusion rocket can be made to work. That's the key to the whole damned thing: efficient propulsion can bring the cost of asteroid mining down to where it's economically viable."

For a long moment Freiberg said nothing. He merely glared at Dan, half angry, half sullen.

At last he mumbled, "I'll make a few calls for you, Dan. That's all I can do."

"That's all I ask," Dan replied, forcing a smile. Then he added, "Plus a ride to the airstrip for George and me."

"What about your cook?"

With a laugh, Dan said, "She goes with the van, old buddy. She only speaks Japanese, but she's terrific in the kitchen. And the bedroom."

Freiberg flushed deep red. But he did not refuse Dan's gift.

SELENE CITY

The customs inspector looked startled when he saw the plastic cage and the four live mice huddled in it among the loose food pellets.

He set his face into a scowl as he looked up at Pancho. "You can't bring pets into Selene."

The other astronauts had sailed through the incoming inspection without a hitch, leaving Pancho to face the grim-faced inspector alone. They had cruised to the Moon without incident, none of the others realizing that Pancho had milked each of their bank accounts for a half-hour's interest. Pancho figured that even if they eventually discovered her little scam, the amount of money involved was too small to fight over. To her, it wasn't the amount so much as the adroitness of the sting.

"They're not pets," she said coolly to the inspector. "They're food."

"Food?" The man's dark eyebrows hiked halfway to his scalp line.

"Yeah, food. For my bodyguard." Most of the customs inspectors knew her, but this guy was new; Pancho hadn't encountered him before. Not bad-looking, she thought. His dark blue zipsuit com-

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plemented his eyes nicely. A little elderly, though. Starting to go gray at the temples. Must be working to raise enough money for a rejuve treatment.

As if he knew he was being maneuvered into giving straight lines, the customs inspector asked, "Your bodyguard eats mice?"

Pancho nodded. "Yes, sir, she does."

The inspector huffed. "And where is this bodyguard?"

Pancho lifted a long leg and planted her softbooted foot on the inspector's table. Tugging up the cuff of her coverall trouser, she revealed what looked like a bright metallic blue ankle bracelet.

While the inspector gaped, Pancho coaxed Elly off her ankle and held her out in front of the man's widening eyes. The snake was about thirty-five centimeters long, from nose to tail. It lifted its head and, fixing the inspector with its beady, slitted eyes, it hissed menacingly. The man flinched back nearly half a meter.

"Elly's a genetically-modified krait. She'll never get any bigger'n this. She's very well-behaved and wicked poisonous."

To his credit, the inspector swiftly recovered his composure. Most of it, at least.

"You . . . you can't bring a snake in," he said, his voice quavering only slightly. "That's against the regulations and besides—"

"There's a special exception to the regulations," Pancho said calmly. "You can look it up. Paragraph seventeen-dee, subclause eleven."

With a frown, the inspector punched up the relevant page on his palmcomp. Pancho knew the exception would be there; she had gone all the way up to the Selene health and safety executive board to get it written into the regs. It had cost her a small fortune in time and effort; many dinners with men old enough to be her grandfather. Funny thing was, the only overt sexual pass made at her was from the woman who chaired the executive board.

"Well, I'll be dipped in . . ." The inspector looked up from his handheld's tiny screen. "How in hell did you get them to rewrite the regs for you?"

Pancho smiled sweetly. "It wasn't easy."

"That little fella is poisonous, you say?"

"Her venom's been engineered to reduce its lethality, but she's still fatal unless you get a shot of antiserum." Pancho pulled a slim vial from her open travelbag and wagged it in front of the inspector's bulging eyes.

He shook his head in wonder as Pancho coaxed the snake back around her ankle. "And he eats mice."

"She," Pancho said as she straightened up again. "When I stay up here for more than a month I have to send Earthside for more mice. Costs a bundle."

"I'll bet."

"The mice never get out of their cage," Pancho added. "Once every other week I put Elly in with them."

The inspector shuddered visibly. He took Pancho's entry forms and passed them in front of the electronic reader. The machine beeped once. Pancho was cleared. The inspector put the transparent mouse cage back into her flight bag and zipped it shut.

"You're OK to enter Selene," he said, almost as if he didn't believe it himself.

"Thank you."

Before she could hoist her bag onto her shoulder, he asked, "Uh . . . what're you doing for dinner tonight?"

Pancho smiled her sweetest. "Gee, I'd love to have dinner with you, but I already have a date."

Dressed in a crisp white pantsuit set off by the flowery scarf she'd tied around her neck, Pancho followed the directions Martin Humphries had videomailed to her.

In Earthside cities, height meant prestige. In hotels and condo towers, the higher the floor, the higher the price.

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Penthouses were considered the most desirable, and therefore were the most expensive. On the Moon, where human settlements were dug into the ground, prestige increased with depth. The airless lunar surface was dangerous, subject to four-hundred-degree temperature swings between sunlight and shadow, bathed in hard radiation from deep space, and peppered with meteoric infall. So in Selene and the other communities on the Moon, the deeper your living quarters, the more desirable it was, and the more expensive.

Martin Humphries must be rotten rich, Pancho thought as she rode the elevator down to Selene's lowest level. According to the biofiles on the nets, Humphries was supposed to be one of the wealthiest men in the Earth/Moon system, but that could be public relations puffery, she thought. The tabloids and scandal sites had more on him than the biofiles. They called him "Hump," or "the Humper." He had a reputation as a chaser, married twice and with lots of media stars and glamour gals from the upper crust, to boot. When Pancho looked up the pix of his "dates" she saw a succession of tall, languid, gorgeous women with lots of hairdo and skimpy clothes.

Pancho felt completely safe: the Humper wouldn't be interested in a gangly, horse-faced tomboy. Besides, if he tried anything Elly would protect her.

He had called her personally. No flunky; Martin Humphries his own self had phoned Pancho and asked her to come to his home to discuss a business proposition. Maybe he wants to hire me away from Astro, she thought. Astro's been a good-enough outfit, but if Humphries offers more money I'll go to work for him. That's a no-brainer. Go where the money is, every time.

But why did he call me himself, instead of having his personnel office interview me?

There were only a few living units carved into the rock this far underground. Big places, Pancho realized as she glided along the well-lit corridor in the practiced bent-kneed shuffle that you had to use to walk in the Moon's low gravity. The walls of the corridor were carved with elaborate low-relief sculptures—mostly astronomical motifs, but there were some Earthly landscapes in with the stars and comets. She counted about a hundred strides between doors, which meant that the living units on the other sides of the corridor walls were bigger than a whole dorm section on the floors above. The doors were fancy, too: most of them were double, all of them decorated one way or another. Some of them looked like real wood, for crying out loud.

But while all this impressed Pancho, she was totally unprepared for Martin Humphries' home. At the very end of the corridor was a blank metal door, polished steel, from the look of it. More like an airlock hatch or a bank vault than the fancypants doors she'd passed along the corridor. It slid open with a soft hiss as Pancho approached within arm's length.

Optical recognition system, she thought. Or maybe he's got somebody watching the corridor.

She stepped through the open doorway and immediately felt as if she'd entered another world. She found herself in a wide, high-ceilinged cavern, a big natural cave deep below the lunar surface. Flowers bloomed everywhere, reds and yellows and green foliage spread out on both sides of her. Trees! She gaped at the sight of young alders and maples, slim white-boled birches, delicately fronded frangipani. The only trees she'd seen in Selene were up in the Grand Plaza, and they were only little bitty things compared to these. After the closed-in gray sameness of Selene's warren of corridors and tightly confined living quarters, the openness, the color, the heady scent of flowers growing in such profusion nearly overwhelmed Pancho. Boulders jutted here and there, the distant walls of the cave and the ceil-

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ing high above were rough bare rock. The ceiling was dotted with full-spectrum lamps, she saw. Jeez, it's like being in Oz, Pancho said to herself.

Like Oz, there was a path winding through the shrubbery, littered with flower petals. Pancho liked that much better than yellow bricks.

She realized that there were no birds singing in the trees. No insects buzzed among the flowers. There was no breeze sighing past. This ornate garden was nothing more than a big, elaborate hothouse, Pancho decided. It must cost a freaking fortune.

She glide-walked along the path until a final turn revealed the house set in the middle of the cavern, surrounded by still more trees and carefully-planted beds of roses, irises and peonies. No daisies, Pancho noted. No marigolds. Too ordinary for this layout.

The house was enormous, low but wide, with a slanted roof and walls of lunar stone, smoothed and glazed over. Big sweeping windows. A wide courtyard framed the big double doors of the front entrance, with a fountain gurgling busily in its center. A fountain! Pancho approached one of the doors slowly, reached out her hand to touch its carved surface. Plastic, her fingertips told her, stained to look like wood. For several moments she stood at the door, then turned to look back at the courtyard again, the gardens, the trees, the fountain. What kind of a man would spend so much money for a private palace like this? What kind of a man would have that much money to spend?

"Welcome, Ms. Lane."

The sound of his voice made Pancho flinch. He had opened the door silently while her back had been turned as she surveyed the greenery. She saw a man apparently about her own age, several centimeters shorter than she, a little on the pudgy side. He was wearing an open-necked pale yellow tunic that came down to his hips. His slacks were cinnamon brown, perfectly creased. His feet were shod in fancy tooled leather boots. His skin was doughy white, his hair dark and slicked back.

"I'm here to see Mr. Humphries," she said. "I've been invited."

He laughed lightly. "I'm Martin Humphries. I gave my staff the night off."

"Oh."

Martin Humphries gestured Pancho to come into his house. Knowing Elly was comfortably wrapped around her ankle, Pancho stepped right in.

The house was just as luxurious as the grounds around it, perhaps even more so. Big, spacious rooms filled with the most beautiful furniture Pancho had ever seen. A living room long enough to hold a hockey rink, sofas done in gorgeous fabrics, holowindows showing spectacular Earthside scenery: the Grand Canyon, Mt. Fujiyama, Manhattan's skyline the way it looked before the floods.

The dining room table was big enough to seat twenty, but it was set for just the two of them: Humphries at its head, Pancho at his right hand. Humphries walked her past it, though, and into a book-lined library where the single holowindow showed the star-strewn depths of space.

There was a bar along one side of the library.

"What would you like to drink?" Humphries asked, gently guiding her to one of the plush-cushioned stools.

"Whatever," Pancho shrugged. A good way to judge a man's intentions was to let him select the drinks.

He looked at her for a fleeting, intense moment. Like being x-rayed, Pancho thought. His eyes were gray, she noted—cold gray, like lunar stone.

"I have an excellent champagne," he suggested.

Pancho smiled at him. "OK, fine."

He pressed a button set into the bar's surface and a silver tray bearing an opened bottle of champagne in a refrigerated bucket and two tall fluted glasses

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rose up to serving height with a muted hum of an electrical motor. Humphries pulled the bottle from its bucket and poured two glasses of champagne. Pancho noticed that the ice-cold bottle quickly beaded with condensation. The glasses looked like real crystal, probably made at Selene's glass factory.

The bubbles tickled her nose, but the wine was really good: crisp and cold, with a delicate flavor that Pancho liked. Still, she merely sipped at it as she sat beside Martin Humphries on the softly cushioned bar stool.

"You must be awful rich to have this place all to yourself," she said.

His lips edged into a thin smile. "It's not mine, really."

"It's not?"

"Legally, this building is a research center. It's owned by the Humphries Trust and operated jointly by a consortium of Earthside universities and the Selene executive board."

Pancho took another sip of champagne while she sorted that out in her mind.

Humphries went on, "I live here whenever I'm at Selene. The research staff uses the other end of the house."

"But they don't live here."

He laughed. "No, they live a few levels up, in . . . um, more ordinary quarters."

"And you get the whole place rent-free."

With a waggle of his free hand, Humphries said, "One of the advantages of wealth."

"The rich get richer."

"Or they lose what they've got."

Nodding, Pancho asked, "So what do they research down here?"

"Lunar ecology," Humphries replied. "They're trying to learn how to build Earth-like ecologies here on the Moon, underground."

"Like the Grand Plaza, up topside."

"Yes. But completely closed-cycle, so you don't have to put in fresh supplies of water."

"That's what all the flowers and trees are about."

"Right. They've been able to make a lovely garden, all right, but it's incredibly expensive. Very labor intensive, with no birds or insects to pollinate the plants. The idiots running Selene's environmental safety department won't let me bring any up here. As if they could get loose! They're so stupidly narrowminded they could look through a keyhole with both eyes."

Pancho smiled at him, remembering how hard it had been for her to get the approval to bring Elly and her food into Selene. I must be smarter than he is, she thought. Or maybe Selene's execs just don't like megazillionaires trying to push them around.

"And those full-spectrum lamps cost a fortune in electricity," Humphries went on.

"Electricity's cheap, though, isn't it?"

Humphries took a long draft of his champagne, then answered, "It's cheap once you've built the solar energy farm up on the surface . . . and the superconducting batteries to store electrical energy during the night. High capital costs, though."

"Yeah, but once you've got the equipment in place the operating costs are pitiful low."

"Except for maintenance."

"Keeping the solar farms clean, up on the surface, you mean. Yeah, I guess that ain't cheap."

"Any work on the surface is damned expensive," he grumbled, bringing his champagne flute to his lips.

"So how rich are you?" she asked abruptly.

Humphries didn't sputter into his champagne, but he did seem to swallow pretty hard.

Pancho added, "I mean, do you *own* any of this or are you just livin' in it?"

He thought a moment before answering. Then, "My grandfather made his fortune in the big dot-com boom around the turn of the century. Gramps was

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smart enough to get into the market while it was still rising and get out before the bubble burst."

"What's a dot-com?" Pancho asked.

Ignoring her question, Humphries went on, "My father took his degrees in biology and law. He bought into half a dozen biotech firms and built one of the biggest fortunes on Earth."

"What're your degrees in?"

"I have an MBA from Wharton and an JD from Yale."

"So you're a lawyer."

"I've never practiced law."

Pancho felt alarm signals tingling through her. That's not a straight answer, she realized. But then, what do you expect from a lawyer? She recalled the old dictum: How can you tell when a lawyer's lying? Watch his lips.

"What do you practice?" she asked, trying to make it sound nonchalant.

He smiled again, and there was even some warmth in it this time. "Oh . . . making money, mostly. That seems to be what I'm best at."

Glancing around the luxurious library, Pancho replied, "I'd say you're purty good at spendin' it, too."

Humphries laughed aloud. "Yes, I suppose so. I spend a lot of it on women."

As if on cue, a generously-curved redhead in a slinky metallic sheath appeared at the doorway to the dining room, a slim aperitif glass dangling empty from one manicured hand. "Say, Humpy, when is dinner served?" she asked poutily. "I'm starving."

His face went white with anger. "I told you," he said through clenched teeth, "that I have a business meeting to attend to. I'll be with you when I'm finished here."

"But I'm starving," the redhead repeated.

Glancing at Pancho, Humphries said in a low voice, "I'll be with you in a few minutes."

The redhead looked Pancho over from head to toe, grinned, and flounced off.

Visibly trying to contain his fury, Humphries said, "I'm sorry for the interruption."

Pancho shrugged. So I'm not invited for dinner, she realized. Should've known.

"Is that your wife?" she asked coolly.

"No."

"You are married, aren't you?"

"Twice."

"Are you married *now?*"

"Legally, yes. Our lawyers are working out a divorce settlement."

Pancho looked straight into his icy gray eyes. The anger was still there, but he was controlling it now. He seemed deadly calm.

"OK," she said, "let's finish up this business meeting so y'all can get down to dinner."

Humphries picked up his glass again, drained it, and placed it carefully back on the bar. Looking up at Pancho, he said, "All right. I want to hire you."

"I already have a job," she said.

"As a pilot for Astro Manufacturing, I know. You've been working for them for more than six years."

"So?"

"You won't have to quit Astro. In fact, I want you to stay with them. The task I have in mind for you requires that you keep your position with Astro."

Pancho understood immediately. "You want me to spy on them."

"That's putting it rather crudely," Humphries said, his eyes shifting away from her and then back again. "But, yes, I need a certain amount of industrial espionage done, and you are ideally placed to do it."

Pancho didn't think twice. "How much money are we talkin' about here?"

CUENCA

Dan Randolph felt a wave of giddiness wash over him as he stood at his hotel window and looked down into the rugged gorge of the Júcar River.

This is stupid, he told himself. You've been in high-rises a lot taller than this.

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You've been on top of rocket launch towers. You've been to the Grand Canyon, you've done EVA work in orbit, for god's sake, floating hundreds of miles above the Earth without even an umbilical cord to hold onto.

Yet he felt shaky, slightly lightheaded, as he stood by the window. It's not the height, he told himself. For a scary moment he thought it was one of the woozy symptoms of radiation sickness again. But then he realized that it was only because this hotel was hanging over the lip of the gorge, six stories down from the edge.

The old city of Cuenca had been built in medieval times along the rim of the deep, vertiginous chasm. From the street, the hotel seemed to be a one-story building, as did all the buildings along the narrow way. Inside, though, it went down and down, narrow stairways and long windows that looked out into the canyon cut by the river so far below.

Turning from the window, Dan went to the bed and unzipped his travel bag. He was here in the heart of Spain to find the answer to the world's overwhelming problem, the key to unlock the wealth of the solar system. Like a knight on a quest, he told himself, with a sardonic shake of his head. Seeking the holy grail.

Like a tired old man who's pushing himself because he doesn't have anything else left in his life, sneered a bitter voice in his head.

The flight in from Madrid had turned his thoughts to old tales of knighthood and chivalrous quests. The Clippership rocket flight from La Guaira had taken only twenty-five minutes to cross the Atlantic, but there was nothing to see, no portholes in the craft's stout body and the video views flashing across the screen at his seat might as well have been from an astronomy lecture. The flight from Madrid to Cuenca, though, had been in an old-fashioned tiltrotor, chugging and rattling and clattering across a landscape that was old when Hannibal had led armies through it.

Don Quixote rode across those brown hills, Dan had told himself. El Cid battled the Moors here.

He snorted disdainfully as he pulled his shaving kit from the travel bag. Now I'm going to see if we can win the fight against a giant bigger than any windmill that old Don Quixote tackled.

The phone buzzed. Dan snapped his fingers, then realized that the hotel phone wasn't programmed for sound recognition. He leaned across the bed and stabbed at the ON button.

"Mr. Randolph?"

The face Dan saw in the palm-sized phone screen looked almost Mephistopholean: thick black hair that came to a point almost touching his thick black brows; a narrow vee-shaped face with sharp cheekbones and a pointed chin; coal-black eyes that glittered slyly, as if the man knew things that no one else knew. A small black goatee.

"Yes," Dan answered. "And you are? . . ."

"Lyall Duncan. I've come to take you to the test site," said the caller, in a decidedly Highland accent.

Dan puffed out a breath. They certainly aren't wasting any time. I'm not even unpacked yet.

"Are you ready, sir?" Duncan asked.

Dan tossed his shaving kit back onto the bed. "Ready," he said.

Duncan was short, rail-thin, and terribly earnest about his work. He talked incessantly as they drove in a dusty old Volkswagen van out into the sun-drenched countryside, past scraggly checkerboards of farms and terraced hillsides, climbing constantly toward the distant bare peaks of the Sierras. The land looked parched, poor, yet it had been under cultivation for thousands of years. At least, Dan thought, it's far enough from the sea to be safe from flooding. But it looks as if it's turning into a brown, dusty desert.

". . . tried for many a year to get someone to look at our work, *anyone*," Duncan was saying. "The universities were

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too busy with their big reactor projects, all of them sucking on one government teat or another. The private companies wouldn't even talk to us, not without some fancy university behind us."

Dan nodded and tried to stay awake. The man's soft Scottish burr was hypnotic as they drove along the winding highway into the hills. There were hardly any other cars on the road, and the hum of the tires on the blacktop was lulling Dan to sleep. Electric motors don't make much noise, he told himself, trying to fight off the jet lag. He remembered that auto makers such as GM and Toyota had tried to install sound systems that would simulate the *vroom* of a powerful gasoline engine, to attract the testosterone crowd. The GEC had nixed that; silent, efficient, clean electrical cars had to be presented as desirable, not as a weak second choice to muscle cars.

". . . none of them wanted to see that a compact, lightweight, *disposable* fusion generator could work as well as the behemoths they were building," Duncan droned on. "No one paid us any attention until we caught the ear of Mr. Martin Humphries."

Dan perked up at the mention of Humphries' name. "How did you reach him? He's pretty high up in the corporate food chain."

Duncan smiled craftily. "Through a woman, how else? He came to Glasgow to give a speech. The anniversary of his father's endowment of the new biology building, or something of that sort. He took a fancy to a certain young lady in our student body. She was a biology major and had quite a body of her own."

With a laugh, Dan said, "So she did the Delilah job for you."

"One of the lads in our project knew her—in the Biblical sense. He asked her if she'd help the cause of science."

"And she agreed."

"Willingly. 'Tisn't every day a lass from Birmingham gets to sleep with a billionaire."

"Oh, she was English?"

"Aye. We couldn't ask a Scottish lass to do such a thing."

Both men were still laughing as the car pulled into the test site's parking lot.

It wasn't much of a site, Dan thought as he got out of the car. Just a flat, open area of bare dirt with a couple of tin sheds to one side and a rickety-looking scaffold beyond them. Rugged hills rose all around, and in the distance the Sierras shimmered ghostlike in the heat haze. The Sun felt hot and good on his shoulders. The sky was a perfect blue, virtually cloudless. Dan inhaled a deep breath of clean mountain air; it was cool and sharp with a tang of pines that even got past his nose plugs. Dan thought about taking them out; it would be a relief to do without them. But he didn't remove them.

There were six people in the "office" shed, two of them women, all but one of them young, wearing shabby sweaters and slacks or jeans that hadn't known a crease for years. Dan felt overdressed in his tan slacks and suede sports jacket. One of the women was tall, with long, lank blond hair that fell past her broad shoulders. She looked like a California surfer type to Dan. Or maybe a Swede. The other was clearly Japanese or perhaps Korean: short and chunky, but when she smiled it lit up her whole face.

They all looked eager, excited to have Dan Randolph himself here to see their work, yet Dan caught a whiff of fear among them. Suppose it doesn't work today? Suppose something goes wrong? Suppose Randolph doesn't understand its value, its importance? Dan had felt that undercurrent in research labs all around the world; even on the Moon.

The one older man looked professorial. He wore baggy tweed trousers and a matching vest, unbuttoned. His long face was framed by a trim salt-and-pepper beard. Duncan introduced him as "Dr. Vertientes."

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"I am delighted to meet you, sir," Dan said, automatically lapsing into Spanish as he took the man's hand.

Vertientes' brows rose with surprise. "You speak Spanish very well, sir."

"My headquarters is in Venezuela." Dan almost added that he'd once been married to a Venezuelan, but that had been too brief and too painful to bring into the conversation.

"We are a multinational group here," Vertientes said, switching to British English, overlaid with a Castillian accent. "We speak English among ourselves."

"Except when we curse," said the Japanese woman.

Everyone laughed.

Much to Dan's surprise, Duncan was the leader of the little group. The tall, distinguished Vertientes turned out to be the group's plasma physicist. Duncan was the propulsion engineer and the driving force among them.

"You know the principle of nuclear fusion," the Scotsman said as he led the entire group out of the office shack and toward the slightly larger shed that served as their laboratory.

Nodding, Dan said, "Four hydrogen atoms come together to form a helium atom and release energy."

"Nuclei," Duncan corrected. "Not atoms, their nuclei. The plasma is completely ionized."

"Yep. Right."

"Seven-tenths of one percent of the mass of the four original protons is converted into energy. The Sun and all the stars have been running for billions of years on that seven-tenths of one percent."

"As long as they're fusing hydrogen into helium," Dan said. To show that he wasn't entirely unlettered, he added, "Later on they start fusing helium into heavier elements."

Duncan gave him a sidelong glance from beneath his deep black brows, then said, "Aye, but it's only hydrogen fusion that we're interested in."

"Aye," Dan murmured.

The laboratory shed wasn't large, but the equipment in it seemed up-to-date. It looked more like a monitoring station to Dan's practiced eye than a research laboratory. Beyond it was a bigger building that couldn't be seen from the parking lot. The group trooped through the lab with only a perfunctory glance at its equipment, then went on to the other building.

"This is where the dirty work gets done," Duncan said, with his devilish grin.

Dan nodded as he looked around. It was a construction shack, all right. Machine tools and an overhead crane running on heavy steel tracks. The sharp tang of machine oil in the air, bits of wire and metal shavings littering the floor. Yes, they worked in here.

"And out there," Duncan said, pointing to a dust-caked window, "is the result."

It didn't look terribly impressive. Even when they stepped outside and walked up to the scaffolding, all Dan could see was a two-meter-wide metal sphere with a spaghetti factory of hoses and wires leading into it. The metal looked clean and shiny, though.

Dan rapped on it with his knuckles. "Stainless steel?"

Nodding, Duncan said, "For the outside pressure vessel. The containment sphere is a beryllium alloy."

"Beryllium?"

"The alloy is proprietary. We've applied for an international patent, but you know how long that takes."

Dan agreed glumly, then asked, "Is this all there is to it?"

With a fierce grin, Duncan said, "The best things come in the smallest packages."

They went back to the lab and, without a word, the six young men and women took their stations along the bank of consoles that lined two walls of the shed. There was an assortment of chairs and stools, no two of them alike, but no one sat down. Dan saw that they

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were nervous, intense. All except Duncan, who looked calmly confident. He cocked a brow at Dan, like a gambler about to shuffle cards from the bottom of the deck.

"Are you ready to see the wee beastie in action?" Duncan asked.

Tired from travelling, Dan pulled a little wheeled typist's chair to the middle of the floor and sat on it. Folding his arms across his chest, he nodded and said, "You may fire when ready, Gridley."

The others looked slightly puzzled, wondering who Gridley might be and what his significance was. Duncan, though, bobbed his head and grinned as though he understood everything.

He turned to Vertientes and said softly, "Start it up, then."

Dan heard a pump begin to chug and saw the readout numbers on Vertientes' console start to climb. The other consoles came to life, display screens flickering on to show multicolored graphs or digital readouts.

"Pressure approaching optimum," sang out the blonde. "Density on the curve."

"Fuel cells on line."

"Capacitor bank ready."

Duncan stood beside Dan, sweeping all the consoles with his eyes.

"Approaching ignition point," said Vertientes.

Leaning slightly toward Dan, Duncan said, "It's set to ignite automatically, although we have the manual backup ready."

Dan got to his feet and stared out the window at the stainless steel sphere out in the scaffold. There was a crackling air of tension in the lab now, and he could feel the hairs on the back of his neck rising.

"Ignition!" Vertientes called.

Dan saw nothing. The metal sphere outside didn't move. There was no roar or cloud of smoke, not even a vibration. He looked at Duncan, then over to the six others, all of them standing rigidly intent at their consoles. Numbers flickered across screens, curves crawled along graphs, but as far as Dan could see or feel, nothing was actually happening.

"Shutdown," Vertientes said.

Everyone relaxed, sagged back a bit, let out their breaths.

"Thirty seconds, on the tick," someone said.

"Power output?" Duncan asked.

"Design maximum. It reached fifty megawatts after four seconds and held it there right to cutoff."

Vertientes was beaming. He turned and clutched Duncan by both shoulders. "*Perfecto!* She is a well-behaved little lady!"

"You mean that's it?" Dan asked, incredulous.

Duncan was grinning too. They all were.

"But nothing happened," Dan insisted.

"Oh no?" said Duncan, grasping Dan's elbow and turning him toward the row of consoles. "Look at that power output graph."

Frowning, Dan remembered a scientist once telling him that all of physics boiled down to reading a bloody gauge.

"But it didn't go anywhere," Dan said weakly.

They all laughed.

"It isn't a rocket," Duncan said. "Not yet. We're only testing the fusion reactor."

"Only!" said the Japanese woman.

"Thirty seconds isn't much of a test," Dan pointed out.

"Nay, thirty seconds is plenty of time," Duncan rebutted.

"The plasma equilibrates in five seconds or less," said Vertientes.

"But to be useful as a rocket," Dan insisted, "the reactor's going to have to run for hours . . . even weeks or months."

"*Sí*, yes, we know," Vertientes said, tapping a finger into the palm of his other hand. "But in thirty seconds we get enough data to calculate the heat trans-

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fer and plasma flow parameters. We can extrapolate to hours and weeks and months."

"I don't trust extrapolations," Dan muttered.

The blonde stepped between them. "Well, of *course* we're going to build a full-scale model and run it for months. For sure. But what Doc Vee is saying is we've done enough testing to be confident that it'll work."

Dan looked her over. California, he decided. Maybe Swedish ancestry, but definitely California.

"We intend to mate the reactor with an MHD generator," Vertientes said, earnestly trying to convince Dan. "That way the plasma exhaust from the reactor can provide electrical power as well as thrust."

"Magneto . . ." Dan stumbled over the word.

"Magnetohydrodynamic," Vertientes finished for him.

The blonde added, "The interaction of electrically-conducting ionized gases with magnetic fields."

Dan grinned at her. "Thank you." She's showing off, he thought. She wants me to know that she's a *smart* blonde, despite her surfer chick looks.

Then he caught Duncan watching him with that sly look in his glittering coal-black eyes, and remembered the student from Birmingham who had convinced Humphries to pay attention to their work. He shook his head ever so slightly, to tell Duncan that he wouldn't need to be convinced that way.

Once he would have scooped up a young available woman and enjoyed every minute of their brief fling together. But not now. He grimaced inwardly at the weird curves fate throws. When Jane was alive I chased every woman I saw, trying to forget her. Now that she's dead I don't want anyone else. Not now. Maybe not ever again.

SELENE CITY

"Don't you intend ever to return to Earth?"

Martin Humphries leaned back in his exquisitely padded reclining chair and tried to hide the dread he felt as he gazed at his father's image on the wall screen.

"I'm working hard here, Dad," he said.

It takes almost three seconds for radio or light waves to make the round-trip between the Earth and the Moon. Martin Humphries used the time to study his father's sallow, wrinkled, sagging face. Even though the old man had made his fortune in biotech, he still refused rejuvenation treatments as "too new, too risky, too many unknowns." Yet he wore a snow-white toupee to hide his baldness. It made Martin think of George Washington, although George was alleged never to have told a lie and anyone who had ever dealt with W. Wilson Humphries knew that you had to count your fingers after shaking hands with the old scoundrel.

"I need you here," his father admitted grudgingly.

"*You* need *me?*"

"Those bastards from the New Morality are pushing more tax regulations through the Congress. They won't be satisfied until they've bankrupted every corporation in the country."

"All the more reason for me to stay here," Martin replied, "where I can protect my assets."

"But what about *my* assets? What about me? I need your help, Marty. I can't fight these psalm-singing fundamentalists by myself!"

"Oh, come on, Dad. You've got more lawyers than they do."

"They've got the whole damned Congress," his father grumbled. "And the Supreme Court, too."

"Dad, if you'd just come up here you'd be able to get away from all that."

His father's face hardened. "I'm not going to run away!"

"It's time to admit that the ship is sinking, Dad. Time to get out while you can.

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Up here on the Moon, I'm building a whole new organization. I'm creating Humphries Space Systems. You could be part of it; an important part."

The old man glared at him for much longer than it took his son's words to reach him. At last he growled, "If you stay up there too long, your muscles will get so deconditioned you won't be able to come back to Earth."

He hasn't heard a word I've said, Humphries realized. He talks and he never listens.

"Dad, I'm in the middle of a very complicated deal here. I can't leave. Not now." He hesitated, then said, "I might never come back to Earth."

Once he heard that reply, his father's image went from its normal unhappy scowl to a truly angry frown. "I want you here, dammit! This is where you belong and this is where you're going to be. That's final."

"Father," said Martin, feeling all the old fear and frustration swirling inside him like a whirlpool pulling him down, drowning him. "Father, come here, come be with me. Please. Before it's too late."

His father merely glowered at him.

"Give it up, Dad," Humphries pleaded. "Earth is finished. Everything down there is going to crash; can't you understand that?"

The old man sputtered, "Dammit, Marty, if you don't listen to me . . ." He faltered, stopped, not knowing what to say next.

"Why can't you listen to me for a change?" Martin snapped. Without waiting for a response, he said, "I'm trying to build an empire up here, Dad, an empire that's going to stretch all the way out to the Asteroid Belt and beyond. I'm putting the pieces together right now. I'm going to be the wealthiest man in the solar system, richer than you and all your brothers put together. Maybe then you'll treat me with some respect."

Before his father could reply, Humphries sat up in his recliner and pressed the stud set into the armrest to terminate the videophone link. The old man's face disappeared from the wall, revealing a holowindow that showed a realtime view of Jupiter as seen by the twenty-meter telescope at the Farside Observatory.

For a long moment Humphries simply sat there, alone in the office he had set up for himself in the house deep below the lunar surface. Then he took a long slow breath to calm the furies that raged inside him. The old man has no understanding of the real world. He's still living in the past. He'd rather go down with the ship than admit that I'm right and he's wrong.

Unbidden, the memory of his drowning engulfed him again. Nine years old. His father insisting that the trimaran was in no trouble despite the dark storm winds that heaved the boat so monstrously. The wave that washed him overboard. The frothing water closing over him. Desperately clawing for the surface but sinking, sinking, can't breathe, everything going dark.

Martin Humphries died at the age of nine. After they revived him, he learned that it had been one of the crew who'd dived into the Sound to rescue him. Watching the boy sink out of sight, his father had stayed aboard the trimaran and offered a bonus to any crewman who could rescue his son. From that moment on, Humphries knew that there was no one in the world he could trust; he was alone, with only his inner fears and yearnings to drive him. And only his money to protect him.

Talking with his father always brought those terrible moments back to mind. And the gasping, choking paralysis that clamped his chest like a merciless vise. He reached into the top desk drawer for his inhalator and took a desperate whiff of the cool, soothing drug.

All right, Humphries thought, waiting for his breathing to return to normal, trying to calm himself. He's going to stay down there and try to fight the New

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Morality until they burn him at the stake. Nothing I say will budge him a millimeter. Very well, then.

I'll stay here in Selene where it's safe and everything's under control. No storms, no rain; a world built to suit me in every detail. From here I can pull the strings just as effectively as if I were down in New York or London. Better, really. There's no reason for me to go Earthside any more.

Except for the divorce hearing, he remembered. I'm supposed to show up in the judge's chambers for that. But I can do even that from here, get my lawyers to make the excuse that I can't return to Earth, I've been on the Moon too long, it would be dangerous to my health. I can get a dozen doctors to testify to that. No sweat.

Humphries laughed aloud. I won't have to be in the same room with that bitch! Good! Wonderful!

He leaned back again and stared up at the ceiling. It was set to a planetarium display, the sky as it appeared above Selene. Briefly he thought about calling up a porno video, but decided instead to put on the latest informational release from the International Astronautical Authority about the microprobes searching through the asteroids in the Belt.

The IAA's motivation for investigating the asteroids was to locate rocks that might one day hit the Earth. They had good tracks on all the hundreds of asteroids in orbits that brought them close to Earth. Now they were sorting through the thousands of rocks out in the Belt big enough to cause serious damage if they were ejected from the Belt and impacted Earth.

The good news was that so far they had not found any asteroid in an orbit that threatened the homeworld—although the asteroids in the Belt were always being jostled by Jupiter and the other planets, their orbits perturbed unpredictably. A constant watch was a vital necessity.

The better news was that, as a byproduct of the impacter watch, the IAA was getting detailed data on the composition of the larger asteroids. Iron, carbon, nickel, phosphorus, nitrogen, gold, silver, platinum, and even water was out there in vast abundance. Ripe for picking. Waiting for me to turn them into money, Humphries told himself, smiling happily.

Dan Randolph will send a team out to the Belt on a fusion rocket. The first mission will fail, of course, and then I'll have Randolph where I want him. I'll take control of Astro Corporation and we can put Randolph out to pasture, where he belongs.

Then a thought clouded his satisfaction. It's been damned near six months since I hired Pancho Lane to keep an eye on Randolph. Why haven't I heard from her?

LA GUAIRA

"Aren't you nervous?" Amanda Cunningham asked.

Sitting beside her as the Clippership returned to Earth, Pancho shook her head. "Nope. You?"

"A bit."

"Uh-huh."

"I mean . . . meeting the head of the corporation. It's rather exciting, don't you think?"

Pancho and Amanda had been summoned to Astro Manufacturing's corporate headquarters in La Guaira, on an island across the strait from Caracas. Something about a new assignment that Dan Randolph himself would decide.

"Well, meeting the big boss is important, I guess," Pancho said as nonchalantly as she could manage.

They were riding the Clippership down from the aging space station *Nueva Venezuela* to the landing field at La Guaira, riding comfortably in the nearly empty passenger cabin with a sparse handful of paying customers rather than in the cramped cockpit where the crew worked. Amanda revelled in the luxury of spacious seats and entertainment

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videos; Pancho figured that something important was waiting for them when they landed, something important enough for Astro to undergo the expense of letting them ride deadhead from Selene.

Well, she said to herself, the pilots up in the cockpit are really deadheading, too. Clipperships flew under control from the ground—they didn't need an onboard crew any more than a ballistic missile did. But even after all these years—decades, really—the politicians refused to allow spacecraft that carried passengers to fly fully automated. The pilots had to go along; there had to be a cockpit and full controls for them even though they had absolutely nothing to do.

Don't complain, she said to herself. If the aerospace lines didn't need to hire pilots you wouldn't have gotten a job in the first place. You'd still be sitting in front of a display screen in some cubicle back in Lubbock doing tech support and barely making enough money to keep Sis alive.

Amanda was flicking through the entertainment channels, eyes locked on her little pop-up screen. Pancho eased back in the comfortable passenger's chair and closed her eyes.

Why me? she asked herself. Why has the CEO of Astro Manufacturing called me all the way back from Selene to see him in person? Amanda I can understand. One look at her ID vid and the Big Boss prob'ly started panting like a dog in heat. Still, Pancho had to admit that Mandy was a damned good pilot, boobs notwithstanding. In the six months since they'd first met, Pancho had acquired a healthy respect for Amanda's piloting skills. This is her first job and she's already as good as I am . . . well, almost. I'm the best pilot Astro's got, flat out, but what's that got to do with seeing the CEO? Why does he want to see me?

Does Humphries have anything to do with this? He wants me to spy on Astro, which means he prob'ly wants me to spy on Randolph himself. So maybe he's worked things out so's I get to see Randolph face-to-face. Is Humphries pulling strings inside Randolph's own company?

It never occurred to Pancho that Dan Randolph wanted to see her for reasons of his own.

The Clippership rode smoothly through re-entry, with only a few moments of turbulence as it plunged into the Earth's atmosphere like a squat, cone-shaped meteor, plummeting so fast that the very air outside the craft heated to incandescence. We're a falling star, Pancho told herself as she sat tightly buckled into her seat while the ship shuddered and jounced. She could hear the muted howl of the tortured air on the other side of the hull, mere centimeters from her seat. A falling star. Some kid down there's prob'ly making a wish on our trail.

The shaking and banshee wail of reentry ended swiftly and the flight smoothed out.

"We'll be landing in four minutes," the captain's rich baritone voice announced over the intercom. "Don't be alarmed by all the banging and roaring. It's just the retrorockets and the landing struts deploying."

Pancho smiled. That's what we need the crew for: reassuring announcements.

It felt as if they were falling until the retros fired briefly, pushing Pancho deep into her seat. Another drop, so short she barely had time to feel it before the retros roared out a longer blast. Then everything went silent and still.

"We're on the ground," the captain said, sounding relieved.

Pancho had expected that she and Amanda would be sent directly to Randolph's office for their interview with the CEO, or at least to the personnel department for a briefing on what they should expect. Instead, once they cleared the access tunnel they were met

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in the terminal by a good-looking young Latino in a business suit who led them out to the garage and a sleek-looking sedan.

"Your luggage is being picked up and will be waiting for you in your quarters at the corporate housing center," he said in impeccable American English, opening the car's rear door for the two women.

As she and Amanda got into the back seat, Pancho saw there was a driver sitting behind the wheel. The young man slid in beside him.

She grinned. "What, no limo?"

The young man half-turned in his seat and said quite seriously, "Mr. Randolph doesn't believe in unnecessary frills. This is comfortable enough, isn't it?"

"Quite," said Amanda.

By the time they got to the test site, Amanda had set up a dinner date for herself with their handsome young escort.

The test site was on the shoulder of a green hillside that sloped down into the warm Caribbean. Late afternoon sunshine slanted down from between massive cumulus clouds that were visibly growing, boiling up into towering thunderheads, getting darker and more menacing by the minute. Pancho smelled the salt tang in the air, heard the surf rolling in gently below, felt the warm steady breeze on her face. A tropical paradise, she thought.

Or, it would be, if it weren't for all that danged hardware squatting in the middle of the field.

Following their Latino escort, they walked from the car to the small knot of people standing around what looked like a set of man-tall dewar flasks crusted with frost, a small crane, lots of plumbing and tubing, a medium-sized truck carrying what looked like a pair of major-league fuel cells on its bed, a smaller truck loaded with a bank of capacitors, and a corrugated-metal shed off to one side. Several automobiles and semivans were parked on the other side of the shed.

As they got closer, Pancho saw that the people were gathered around a small swept-winged aircraft that was resting on a pair of skids. It was an ancient cruise missile, she saw, an unmanned jet airplane. She knew they'd been outlawed by the disarmament treaties. Only the Peacekeepers had such weapons, and this one looked too old to be a Peacekeeper missile. The markings on it were faded, the serial number stencilled on its tail barely legible.

Before she could ask a question, a trim-looking man with silver hair and a rugged fighter's face stepped out of the crowd around the missile. He wore a light tan windbreaker zippered to the throat despite the warm sunshine, a baseball cap perched jauntily on his head, well-faded jeans and cowboy boots. Their escort stiffened almost like a soldier coming to attention.

"Señor Randolph," he said, "may I introduce—"

"You must be Amanda Cunningham," said Dan Randolph, with a crooked smile. He put his hand out and Amanda took it briefly. "I'm Dan Randolph."

Then he turned to Pancho. "And you've got to be Priscilla Lane."

"Pancho," she corrected, taking his extended hand. His grip was firm, friendly. "Priscilla's too fussy, and anybody calls me Pru or Prissy, I'll belt him."

"Pancho," Randolph said, his smile widening. "I'll remember that."

"What's this all about?" Pancho asked. "Why've you brought us here?"

Randolph's eyes showed momentary surprise at her bluntness, but then he shrugged and said, "You're going to see some history being made . . . if this double-damned jury-rigged kludge works right."

He introduced Amanda and Pancho to Lyall Duncan and the others gathered around the missile. Almost all of them were male, engineers or technicians.

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One of the women was a tall blonde; competition for Amanda, Pancho thought. Duncan looked like a fierce little gnome, or maybe a troll, even when he smiled.

Puzzled, intrigued, Pancho allowed Randolph to usher her and Amanda to the shed. It was packed with instruments and consoles and one rickety-looking desk with a lopsided chair in front of it.

"You just stay here and watch," he said, with a curious grin. "If it works, you'll be witnesses. If it blows up, this ought to be far enough away to keep you from getting hurt."

The dark-haired troll called Duncan chuckled. "Experimental physics, you know. Always the chance of an explosion."

The crane was on its own caterpillar tractor. A pair of technicians used it to hoist the missile off the ground and trundle it out almost half a kilometer. They put the missile gently onto the grassy ground, pointed into the wind blowing steadily in from the sea.

Consoles were coming to life in the shed. Engineers were speaking to each other in their clipped jargon. Pancho watched Randolph. The man seemed outwardly relaxed as he stood with both hands jammed into his windbreaker pockets, watching the missile while the crane waddled back toward them.

Duncan buzzed around the shed like a bee in a flower bed. The tension built up; Pancho could feel it radiating from the backs of the crew standing by the consoles.

"Do you think it's going to rain?" Amanda whispered.

Pancho looked up at the looming thunderheads. "Sooner or later."

At last Duncan said to Randolph, "We're ready to launch."

"OK," said Randolph. "Do it before it starts pouring."

Duncan said crisply, "Launch!"

Pancho turned her attention to the missile sitting out on the grass. For a moment nothing happened, but then its tail end spurted flame and it lurched forward. Just as she heard the whining scream of the jet engine, another sound cut in, a deeper, more powerful roar. The missile leaped off the ground, angling sharply toward the cloud-filled sky, trailing a billow of smoke.

Something fell away from the climbing missile. A rocket pack, Pancho realized. They used it to get the bird off the ground.

The plane levelled off a scant hundred meters in the air and circled the field once.

"Nominal flight," one of the engineers called out.

"Fusion drive ready?" Duncan asked.

"Primed and ready."

"Light it."

The missile seemed to falter for a moment, as if it had stalled in midair. Pancho saw the slightly smokey exhaust wink out, heard the jet engine's screech die away. The missile glided for several moments, losing altitude.

Then it seemed to bite into the air, raised its nose and climbed steeply upward as it howled a thin, screeching banshee wail.

"Programmed flight trajectory," Pancho heard someone call out. "On the money."

The bird flew out to sea until it was a barely visible speck, then turned back and rushed toward them, climbing almost to the base of the thunderheads, its ghostly wail barely audible, streaking past, heading inland. Then it turned again and headed seaward once more. Racetrack course, Pancho realized.

Lightning was flickering in the clouds now.

"Coming up on the two-minute mark," said one of the engineers. "*Mark!* Two minutes."

"Bring her in," Duncan commanded.

"Automatic trajectory," came the answer.

Pancho watched as the missile turned back toward them once again, dropped

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its flaps, slowed, and gracefully descended for a landing out in the area where it had taken off. The grass was scorched out there from the takeoff rocket's hot exhaust.

Turning slightly, she saw that Randolph was standing just outside the door, eyes riveted to the approaching missile, mouth slightly open, fists clenched.

The missile was still moving fast when it touched the ground, bounced into the air again, wobbled back to the ground and then plowed nose-first into the dirt, throwing a spray of grass clods and pebbles as it flipped over onto its back and banged down so hard one of the wings tore off. It sounded like a junkyard falling out of the sky.

But the engineers and technicians were all cheering, jumping up and down, pounding each other on the back, yelling and waving like a team that had just scored a gold medal in the Olympics. Randolph yanked off his cap and pegged it out toward the sea.

"Och, what a divot!" Duncan shouted. He raced through the open door to Randolph and launched himself into the older man's arms, wrapping his legs around Randolph's middle. Randolph staggered backward and they fell to the ground together, laughing like maniacs.

Pancho looked at Amanda. She seemed just as puzzled as Pancho felt.

With a shrug, Pancho said, "I guess any landing you can walk away from is a good landing."

Amanda shook her head. "I shouldn't think you'd walk away from that one if you'd been aboard it."

Randolph was disentangled himself from Duncan and getting to his feet. Brushing dirt from his windbreaker, grinning hugely, he walked over to Amanda and Pancho while Duncan scampered toward the shed.

"It works!" Randolph said. "You've just witnessed history, ladies. The first actual flight of a fusion-powered vehicle."

"Fusion?" Pancho gaped at him. "You mean that little bird had a fusion engine on her?"

Amanda said, "But I thought fusion generators were great immense things, like power stations."

Duncan raced back to them, waving a dark bottle in one hand. The rest of the crew gathered around. Pancho wondered why no one went to the poor little aircraft, smashed and crumpled on the grass.

Someone produced paper cups and Duncan began to splash liquor into them. At first Pancho thought it was champagne, but the bottle wasn't the right shape. Scotch, she realized. Scotland's gift to the world.

"Hey," said Randolph, "I need some ice with this."

Duncan actually shuddered. "Ice? With good whisky? You Americans!"

Pancho took a sip of hers, neat. "Wow!" she managed to gasp.

"To the Duncan Drive," Randolph toasted, lifting his paper cup.

"To the stars!" Duncan countered. "We'll ride this engine to Alpha Centauri one day!"

Randolph laughed. "The Asteroid Belt will be far enough, for now."

A couple of the men quaffed their drinks down in one gulp, then trotted out toward the wrecked cruise missile. Others headed for the shed.

"Check the cameras, too," Duncan called after them.

Pancho asked Randolph again, "That little ship has a fusion engine in it?"

Nodding, Randolph replied, "In place of its warhead."

"The engine's that small?"

"It's only a wee test engine," said Duncan. "Just to prove that it can provide controllable thrust."

"Now we can build one big enough to carry a real payload to the Belt," Randolph said.

"Once you raise the money," added Duncan.

With a glance at Amanda, Pancho

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asked Randolph, "But why did you bring Mandy and me out here? Just to have a couple more witnesses?"

His grin growing even wider, Randolph answered, "Hell no. I wanted you to see this because you two are going to pilot the first fusion rocket to the Asteroid Belt."

LA GUAIRA

Pancho looked up, bleary-eyed, from her desktop screen. Across the room that she and Amanda were sharing, Mandy sat at her desk with virtual reality glasses and earphones covering half her face, peering intently at her own screen.

"I'm goin' for a walk," she said, loudly enough to get through Mandy's earphones.

Amanda nodded without taking off the VR glasses. Pancho squinted at the screen, but it was nothing but a jumble of alphanumerics. Whatever Mandy was studying was displayed on her glasses, not the computer screen.

Their dorm room opened directly onto the patio. Cripes, it's almost sundown, Pancho saw as she stepped outside. The late afternoon was still tropically warm, humid, especially after the air-conditioned cool of their quarters.

Pancho stretched her long arms up toward the cloud-flecked sky, trying to work out the knots in her back. Been settin' at that stupid ol' desk too damned long, she said to herself. Mandy can sit there and study till hell freezes over. She's like a dog-ass computer, just absorbing data like a friggin' machine.

Dan Randolph had put them to studying the fusion drive and working with the engineering team that was converting a lunar transfer buggy into the ship that would carry them out to the Belt. They saw Randolph rarely. The man was jumping all across the world like a flea on a hot griddle, hardly ever in the same place more than one night. When he was in La Guaira he drove the whole team hard, and himself hardest of all.

Peculiar place for a corporate headquarters, Pancho thought as she walked from the housing complex out past the swaying, rustling palm trees, toward the seawall. La Guaira was more suited to being a tourist resort than a major space launching center. Randolph had settled his Astro Manufacturing headquarters here years ago, partly because its location near the equator gave rockets a little extra boost from the Earth's spin, partly because he found the government of Venezuela easier to deal with than the suits in Washington.

Strange, though. Randolph was rumored to have been in love with President Scanwell. There were whispers about their being lovers, off and on, a stormy romance that only ended when the ex-President lost her life in the big Tennessee Valley earthquake.

It all seemed so far away. Pancho followed the winding path toward the seawall, her soft boots crunching on the gravel. The Sun was just about touching the horizon, turning the Caribbean reddish gold. Massive clouds were piling up, turning purple and crimson in the underlighting. With the breeze coming off the sea, making the palms bow gracefully, this was as close to a tropical paradise as she could imagine.

But the seawall reminded her of a harsher reality. It was shoulder high, an ugly reinforced-concrete barrier against the encroaching waters. It had originally been painted a pastel pink, but the paint had faded in the sun and the concrete was crumbling here and there, where storm tides had pounded against it. The old beaches were all underwater now, except at the very lowest tides. The surf broke out there, long combers tumbling and frothing with a steady, ceaseless growling hiss. And still the sea was rising, a little bit more every year.

"Looks pretty, doesn't it?"

Startled, she turned to see Randolph standing there, looking glumly out to sea. He was wearing a wrinkled white shirt and dark slacks that had gone baggy from long hours of travel.

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"Didn't see you coming up the path, boss," said Pancho. "Come to think of it, I didn't even hear you on the gravel."

"I walked on the grass," Randolph said, quite seriously. "Stealth is my middle name."

Pancho laughed.

But Randolph said gloomily, "When Greenland melts down, this will all go under."

"The whole island?"

"Every damned bit of it. Maybe some of the gantry towers will stick up above the surface. The hilltops. Not much else."

"Cripes."

"This used to be part of the mainland, you know. When I first brought the company here, that strait cutting us off from the hills didn't exist. The sea level's gone up that much in less than twenty years."

"And it's still goin' up," Pancho said.

Randolph nodded gloomily, then leaned his arms on the shoulder-high sea wall and propped his chin on them.

"How's the job going?" he asked.

"We're workin' at it," she replied. "It's a lot to learn, all this fusion stuff."

With a tired nod, he said, "Yeah, but you've got to know every bit of it, Pancho. If anything breaks down out there, you've got to be able to diagnose it and fix it."

"We'll have an engineer on board," she said. "Won't we?"

"Maybe. But whether you do or not, *you've* got to know everything there is to know about the systems."

"Yeah. I guess."

"And you've got to get the new navigational technique down, too," he added.

"Point and shoot, yeah. Kinda weird."

With the thrust and efficiency of the fusion rocket, their spacecraft did not have to travel in an energy-conserving ellipse from Earth orbit to the Belt. Fusion-driven trajectories were almost straight lines: travel times would be days instead of months.

"It's a lot to learn, I know," Randolph said.

She saw the weariness in his eyes, and yet there was something else in them, something more. Hope, she thought. Or maybe just plain mulish stubbornness. He wants to make this fusion ship work. And he's trusting me to drive it. Me and Mandy.

"We could use a weekend off," she said. "Or even a night on the town."

The Sun had sunk behind the mainland's mountains. They could see the lights on the mainland beginning to wink on.

"Sorry, kid, no can do," Randolph said. He started walking along the seawall. "I told you when you agreed to take this assignment, you stay here in the complex."

"Security, yeah, I know," Pancho said, following him.

"Your own security, too," Randolph said. "Not just the company's. You're very valuable now. You and Amanda are crucial to this entire operation. I don't want you running any risks."

Pancho thought it over. He's trusting us with this whole operation, right enough. Can't blame him for being careful. Still . . .

She looked across the strait again at the lights of the city.

Then a new thought struck her. Does he know I'm supposed to be snooping on him? Is he keeping us bottled up here so's I can't get in touch with Humphries?

"Can I ask you somethin'?"

Randolph smiled tiredly at her in the fading light. "Sure. Go right ahead."

"I've heard rumbles that you were—well, that Astro's got money problems."

Randolph hesitated a moment. Then, "Corporations always have money problems."

"I mean, like, you're purty close to broke."

"Pretty close," he admitted.

"Then why're you sinkin' all this money into the fusion ship?"

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The light was dying fast. Pancho could barely see his face. But she heard the determination in his voice.

"Two reasons, kid," he said. "First, if it works, Astro can get first licks at the Belt. Our stock will zoom up, our profits will skyrocket, and the only money problems I'll have is how to spend all the cash flowing in."

Pancho said nothing, waiting for his second reason.

"And also," Randolph went on, "opening up the Belt is crucial for the human race's survival."

"You really think so?"

He stopped walking and turned toward her. "We can't take much more of this climate warming, Pancho. Millions have died already, tens of millions. But the worst is yet to come. If Greenland goes—"

"And Antarctica," she interjected.

"And Antarctica," he agreed. "If they melt down, civilization drowns. Billions will die, not just from the floods but from starvation and disease. We can't support the Earth's population now, for god's sake! There's famine in half the world, and it's getting worse, not better."

"You think the asteroids can help?"

"We need those natural resources. We have to rebuild our industrial base, rebuild our wealth."

"In space."

"Yep. Where we should've been building for the past half-century."

Pancho made a low whistle. "That's a big order, boss."

"You're damned right it is. But if we fail, the human race fails. Only a handful of people will live through this, and they'll be thrown back to a preindustrial level: Subsistence farming. No electricity. No machinery. No medicines."

"The Middle Ages."

"More like the Stone Age," Randolph grumbled.

"That's why you're hangin' everything on this flight to the Belt."

She couldn't see his face in the deepening darkness, but she sensed him nodding.

"Everything I've got," he said flatly.

Everything he has. The enormity of it suddenly hit Pancho like an avalanche. He's risking everything he has on this flight, his whole company, his whole life. He's willing to gamble everything he's worked for and built up over his lifetime on this one mission. And he's trusting me to fly it for him. Me.

The responsibility felt like the weight of the world on her shoulders.

"Lemme ask you somethin' else," Pancho said, her voice trembling slightly. "Why'd you pick me to make this flight? You've got lots of other pilots with more experience."

Randolph chuckled softly. "More experience, sure. But they've got families to support. Spouses. Kids."

I've got a sister, Pancho thought. But she said nothing.

"Besides," Randolph went on, "none of them have your abilities."

"My abilities?"

"Listen, kid, I went through every scrap of data on every pilot in Astro's employ and quite a few who aren't on the company's payroll. You came out on top. You are the best we've got."

Pancho felt suddenly breathless. Hell, I know I'm good, but am I really *that* good?

"Before you ask for a raise," Randolph said, "I've got to tell you that my personnel people don't agree with me. They think you're a flake."

"Whattaya mean, a flake?" Pancho demanded.

"The rap on you, kid, is that you're not serious. You like to take risks, play games."

"Not with my flyin'."

"Oh no? Like the time you raced Wally Stinson from Selene to the Farside site?"

"Aw, c'mon, I was only havin' some fun," Pancho protested. "Wally let his testosterone do his thinkin' for him."

"And this bet a few months ago about vacuum breathing?"

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"That was just a hoot."

He chuckled in the growing darkness, but then said, "You're a gambler, Pancho. That scared the hell out of the personnel gurus."

"I won't gamble with your fusion ship," she said firmly.

Randolph was silent for a few heartbeats, then he said, "I know you won't, Pancho. That's why I picked you to fly her."

"What about Amanda?" she heard herself ask. "She's better'n me, isn't she?"

"She's got more education, she's more cautious. But she's not better than you. Close, but not better. Anyway, if you go, I want you to have another woman pilot with you. Guys get funny ideas after a couple of weeks locked up in an aluminum can."

The plan was to carry an engineer/technician and at least one geologist or planetary astronomer on the flight. The mission was designed to be more than a mere test of the fusion drive; it was supposed to bring back results. It had to.

"I can handle the guys," Pancho said.

"Yep, I'm sure you can. But why bring up the problem?"

"You don't think Mandy'll cause a problem?"

Randolph laughed softly in the darkness. "I see your point. She can raise temperatures when she wants to."

"Even when she doesn't want to."

"I had a long talk with Amanda yesterday. She's going to be prim and proper during the flight. No bedroom eyes. No tight uniforms. She agreed to behave herself."

Pancho was shocked. The little sneak never said a word to me about talking with the boss.

"She'll be strictly business. She promised."

"I don't know if she can help herself," Pancho said.

"You think I should take her off the mission?"

Pancho blurted, "No, I think you should take me off it."

"You? Why?"

Don't do it! she raged at herself. Don't go blabbing it out to him. He'll fire your butt out of here like a hot rocket and then make sure nobody'll ever hire you again. But he *trusts* me. He's hangin' his whole world on me because he trusts me to get the job done even when his personnel office doesn't.

"Why should I take you off the mission?" Randolph insisted.

Cursing herself for six kinds of a fool, Pancho said, "Martin Humphries hired me to spy on you."

"He did, huh?" In the starlit darkness, Randolph sounded much less surprised than she thought he would. "When was this?"

"More'n six months ago," Pancho said, barely able to get the words out. "Last time I was up at Selene."

Randolph fell silent and resumed pacing slowly along the seawall. Pancho walked beside him, listening to the sighing of the wind, the grumble of the surf, waiting for him to explode or snarl or say *something*.

At last he started to laugh. Not loud, joyful laughter. Just a low, cynical snickering. "I knew the sonofabitch would try to plant snoops in my drawers, but I never figured he'd recruit you."

"You can fire me if you want to."

"What did he offer you?"

"Money."

"Is that all you're after?"

Pancho hesitated a heartbeat. "I got . . . family to take care of."

"Your sister, yes, I know."

"You know?"

"I told you, I went over every nanobit of data about you. I know about your sister."

"Well . . ." Pancho had to take a breath before she could repeat, "You can fire me, I guess." She was surprised at what an effort it was to say the words.

"Why would I do that?" Randolph sounded genuinely puzzled.

"'Cause I'm supposed to be spyin' on you."

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"That's all right. No need to panic, kid. Go ahead and spy all you want. I knew he'd plant a few spooks into Astro. I'm glad you told me about it. I appreciate your honesty—and loyalty."

"But—"

"No, no, it's OK," Randolph said, his tone almost bantering now. "You go ahead and report everything you're doing to him. I'll even make it easier for you. I'll transfer you and Amanda to Selene. That's where the sonofabitch is living, isn't it?"

"I think so, yeah."

"Good," Randolph said. "I ought to go there myself. It's a lot healthier there than here, that's for sure."

"Healthier?"

"Climate-controlled. Decontaminated air. I don't need filter plugs stuffed up my nose when I'm there."

Before Pancho could ask why he needed filter plugs at all, Randolph grasped her by the shoulder and turned her gently to look up into the darkening sky. A half Moon rode among the scudding clouds, the unwinking brilliant beacon light of Selene visible along its terminator between night and day.

"That's where you're going, kid. To Selene."

Pancho wondered if Randolph was truly pleased with her confession, or if he was exiling her to the most remote spot he could find. ■

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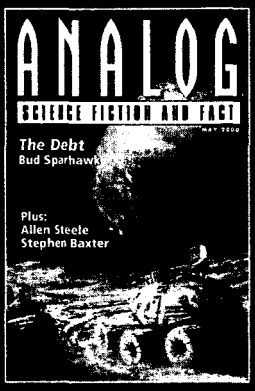

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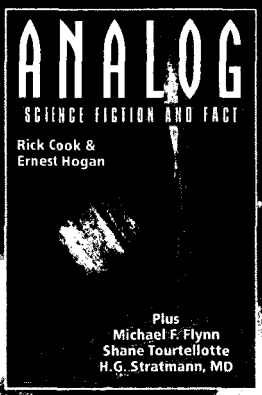

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Water, Pink Salt and Cold Dry Gullies: Halobacteria and the Case for Life on Mars

Geoffrey A. Landis

The Pink Playas

Standing on the plain of Owens Valley, fifty miles west of Death Valley in the great Nevada basin, you may feel you are in one of the most desolate places on Earth. Barren mountains shimmer in the distance. On the ground, the playas—dry lakes—are flat salt deserts. If you drop down to your knees to taste the salt flat, it is intensely bitter and salty.

But the salt is not white; it is a startling bright pink, so intense as to be nearly purple. Owens Lake itself—dry now except during exceptionally wet years—is decorated in pink. It looks like it could be Mars itself, but the pink color is not the iron-oxide rust of the dry Martian dunes. It is something even more strange.

It is life.

Water in the Desert

I was in Huntsville during the press conference when Mike Malin and Ken Edgett announced that, after examining ten thousand images from the Mars Global Surveyor, they had found evidence of the flow of liquid water on Mars.

Liquid water!

This destroys the conventional wisdom about Mars. Not only does Mars have no liquid water, the wisdom says, it *can't* have liquid water. Mars is too cold, and more importantly, the atmosphere of Mars, averaging only 6 millibars, is barely more than a vacuum. The average pressure is below the triple point of water, and so liquid water cannot exist. As the temperature rises, instead of melting into liquid, ice sublimes directly into vapor, with no liquid phase at all. Malin and Edgett state the conventional wisdom in the very first paragraph of their *Science* paper announcing their findings: liquid water cannot exist on Mars.

Conventional wisdom is, however, wrong. While the average pressure is below 6 millibars, in low-lying places on Mars the atmospheric pressure is higher than 6 millibars. At the bottom of the Hellas basin, the lowest place on Mars, the pressure rises to 12 millibars—still barely one percent of the atmospheric pressure at the surface of Earth, but high enough for liquid water to exist, briefly, in the narrow temperature range from zero to ten degrees Celsius.

But this does not explain the finding of liquid water on Mars, since Malin and Edgett's finds were not restricted to low-lying areas.

But there is another point. Mars is salty.

The triple point of distilled water might be 6.1 millibars, but water on Mars is unlikely to be fresh. The Martian soil contains an abundance of salts, and all the salts of Mars will tend to be con-

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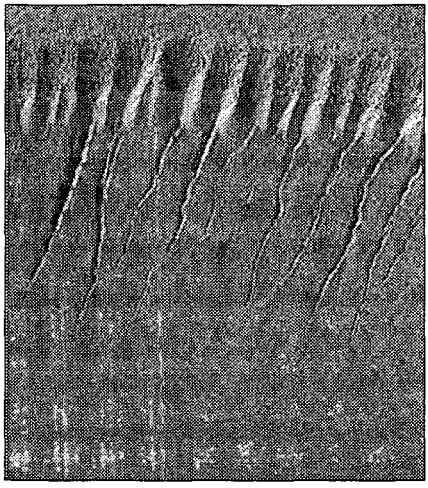

1. Signs of liquid water on Mars? This photo, taken by the Mars Global Surveyor spacecraft, shows dry gullies carved in the side of a slope. It is apparent from the photo that the liquid that caused this erosion came, not from the top of the slope, but from a layer partway down: an aquifer. To give a sense of scale, the area shown here is about one mile wide. (Image courtesy NASA/JPL/Malin Space Sciences).

centrated into whatever liquid water might exist. Saltwaters—brines—have lower freezing points and (more importantly) decreased vapor pressure.

Present-day water on Mars would be a saturated salt solution. Ordinary table salt, NaCl, lowers the freezing point to -19°C. Other dissolved minerals lower the freezing point even further. Potassium carbonate, for example, will depress the freezing point of water to -37°C. Multicomponent aqueous salt solutions can have freezing temperatures below -60°C. Water in the micron-scale crevices between fine grains of sand or in the pores of a water-permeable rock would have an even lower freezing point due to the capillary-pore effect: confined in small volumes, surface tension lowers the freezing point even further.

Pure water may not be able to remain liquid for long on the surface of Mars, but a saturated brine, and especially a brine that is confined between the grains of a fine, porous sand, certainly could. While a standing pool of liquid water on the surface of Mars would eventually evaporate over extended periods of time, it is quite reasonable to expect the transient presence of liquid water at selected surface locations on Mars.

The evidence that Malin and Edgett found for liquid water was subtle, but very clear. In over a hundred places around Mars, liquid water has carved distinctive runoff gullies down hillsides. (An example of one of these sites, with many of these eroded channels carved in the side of the slope, is shown in figure 1.) The runoff channels start at a distinct level below the surface, indicating a water table. "We see features that look like gullies formed by flowing water," Malin stated. "We think we are seeing evidence of a groundwater supply, similar to an aquifer." And, most important of all, the geological evidence shows that they are recent: not covered by craters, unsullied by erosion.

Some geologists argue that the gullies show fluid erosion, but it is not clear that the fluid is water. But so far no other explanation is convincing. The evidence indicates that liquid water is present in water-saturated rocks at a "water table" level below the surface. On the pole-facing hillsides, where a slope cuts through the aquifer level, the water is blocked by an ice dam. When summer melting weakens the ice dam, the water can break through and cascade down, carving a distinctive outflow channel down the hillside.

More intriguing are the suggestions that the torrent, after breaking through a natural dam to reach the surface, actually flows and puddles on the surface. One crater in the southern hemisphere shows the evidence of pooling. In figures 2 and 3, a dried lake is visible at the bottom of a crater, fed by outflow that flowed from the level where the crater walls cut through the aquifer level.

The Doomed Oceans

Aside from the evidence of under-

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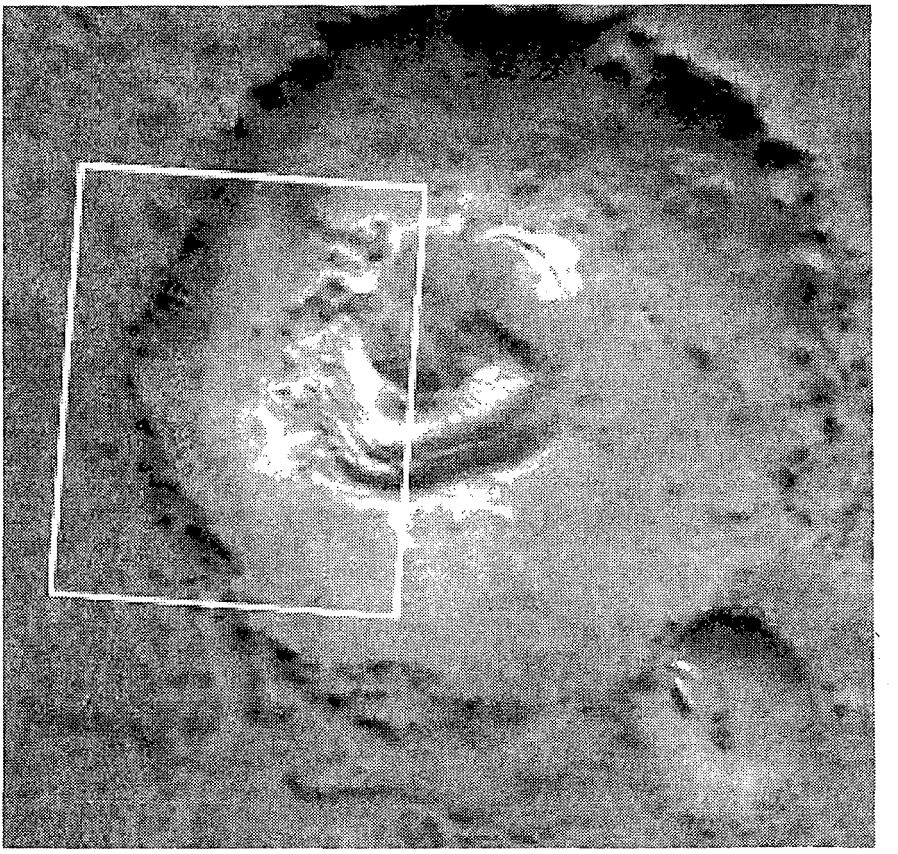

2. An unnamed crater in the southern hemisphere of Mars. Apparent ponding can be seen at the bottom of the crater. The area shown is viewed close-up in figure 3. (Viking image, courtesy NASA.)

ground water found by Malin and Edgett, the surface of Mars is dry.

But it was not always dry.

Ancient channels—possibly a billion years old or more—show that water once existed on the surface of Mars. Cold, dry Mars was once warmer and wetter.

How could a planet so far from the Sun have once been warmer? The answer is the greenhouse effect. The same effect that is feared down here for its possible role in raising the temperature of the Earth would have been a life-inducing effect on Mars.

If the atmosphere of Mars was once much thicker than it now is—maybe two or three times thicker than the Earth's atmosphere—the carbon dioxide would make a greenhouse effect that would trap heat. Carbon dioxide clouds in the upper stratosphere would have an additional effect. CO_2 ice crystals have the unusual property of being much more reflective in the infrared than in the visible; ice crystals in the stratosphere would serve almost as heat-reflecting mirrors to trap the thermal radiation.

There is evidence that not only was Mars once warm enough for liquid water; it even had an ocean. Data from the

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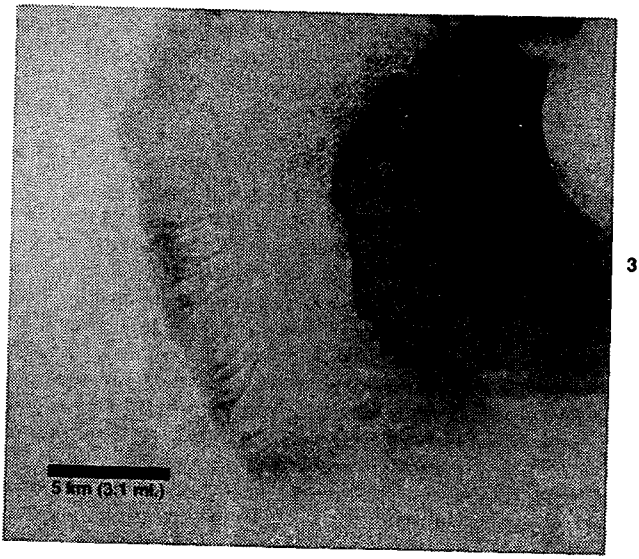

3. A high-resolution view from the Mars Global Surveyor of the wall and bottom of the crater shown in figure 2. The grooves formed by seeping fluid from the aquifer layer can be clearly seen, as well as an apparent dry pond at the crater bottom. (MGS image, courtesy NASA/JPL/Malin Space Sciences)

laser altimeter on the Mars Global Surveyor has given us some exacting measurements of the topography of Mars (figure 4). The low basin of the northern hemisphere shows smoothed terrain, as if it had been underwater. And at the interface between the rougher above-water highlands and the smoothed basin is evidence of a shoreline. Evidence of salt in a Mars meteorite also suggests that the planet once, eons in the past, had a salty ocean.

As an interesting note, the moons of Mars are tiny, but the tides on Mars would have been huge. The mass of the larger moon, Phobos, may only be 0.2% of the mass of the Earth's Moon, but it's 41 times closer than our Moon is. The effect of tides is proportional to the distance cubed, and so the tides on a Martian ocean will be over a hundred times higher than the tides on the Earth.

Whether or not Mars once had an ocean—and the evidence is still hotly debated—it did, in its ancient past, have surface water. What we have learned about the history of the Earth is that, within a few hundred million years (or less) after the surface of the Earth cooled enough to allow liquid water to accumulate, the first life showed up. If Mars once had liquid water, if it once had oceans, then from everything we think we know about life, it should have happened on Mars.

Over the course of a billion years, Mars lost its thick young atmosphere. No one knows for certain where it went. Mars has almost no magnetic field, and with no magnetic protection the solar wind rips at the planet. Over a billion years, this slow solar-wind erosion may have ionized and carried away much of the atmosphere. Some of the atmosphere may have chemically reacted with the rock, and frozen into the polar ice. We don't know where it all went, but for whatever reason, it is gone now, and the atmosphere of Mars is now far too thin and too dry to create a greenhouse effect to warm Mars.

The battle to keep Mars warm was lost long ago.

The Strange Interlude of the Mars Meteoroid

For one summer, scientists believed that they had found signs that life had existed on Mars. A meteoroid found in Antarctica, ALH84001, had many fea-

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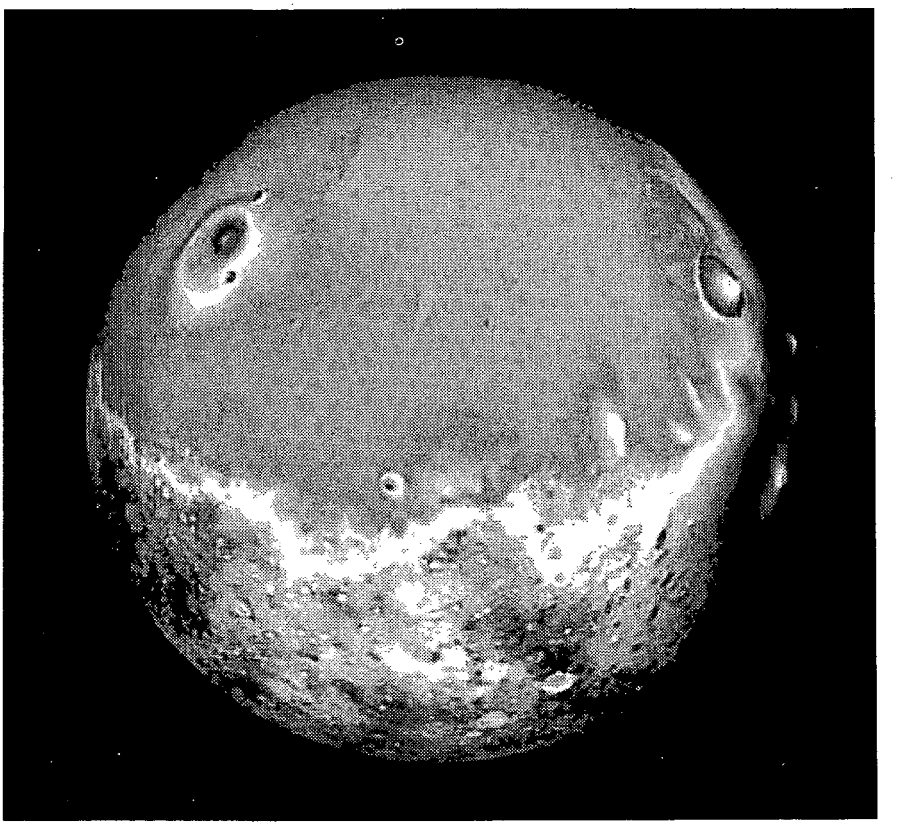

4. An ocean on Mars? This topographical view of Mars, from the laser altimeter on the Global Surveyor spacecraft, shows the smooth low area of the northern hemisphere and the rough highlands in the south. Could the smooth basin in the north be an ancient ocean bottom? (Image courtesy NASA).

tures that indicated it had originally been formed on Mars. (Trapped gas in the meteoroid, for example, had the composition and isotope ratio characteristic of Mars, and carbonate nodules indicated that it originated on a body that had once had both carbon dioxide and water.) Using electron microscopy to examine carbonate veins in the interior of the meteorite, scientist David McKay and his team reported five features that, on Earth, are usually associated with life: polycyclic hydrocarbon rings, magnetite grains, elongated griegite grains, carbon 12/13 isotope fractionation, and—most visually impressive—tiny elongated shapes resembling (but smaller than) filamentous bacteria that were dubbed "nanofossils".

Their paper discussing these results was rather cautious, stating that the results were "possible evidence for" life. But the press outcry—"Scientists claim life on Mars"—soon outstripped any caution.

And now, four years later, after the outcry has died down? No resolution. The scientists who published the original work have not backed down. They continue to say that the best explanation for what they had found in the ALH meteoroid is that it is evidence for life. And

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other scientists who criticized the work continue to state that the evidence is inconclusive, and can be fit with other explanations.

There may have been life on Mars; there may be fossils in Martian rocks. But, until we go there with a rockhammer and a microscope, nobody can yet prove or disprove it. The "Mars Meteorite" controversy ended in a draw.

Life in the Dead Sea

On the planet Earth, life has colonized all ecological niches. From the freezing valleys of Antarctica to the boiling springs of Yellowstone, some form of life is to be found in every environment in which water exists in liquid state for at least a brief portion of the year. Quoting from astronomer Donald Goldsmith: "No water, no life. Everything we know about the conditions under which Earth life can survive leads us to conclude that the presence of liquid water is a requirement for life."

The surface of Mars is harsher than any environment on Earth. Colder than Antarctica, dryer than the Gobi, with air thinner than the top of Everest, and no oxygen in the atmosphere. And yet another hazard exists on Mars: ultraviolet radiation. Lacking an oxygen atmosphere, Mars has no ozone layer, and the surface of Mars is exposed to ultraviolet radiation in an intensity that would serve for a sterilizing treatment on Earth. Even if there is water, Mars is harsh.

Yet could life somehow still exist in the freezing brine of Martian springs?

Salt is deadly to life. On the Earth, salt has been used as a preservative since ancient times. The reason for this is simple: high salt concentrations kill bacteria.

The Dead Sea, and the salt deserts surrounding it, is one of the harshest environments on Earth. The word "dead" is well-advised; it is so-called because no animals live in its mineral-saturated brine.

But on a microbial level, even the Dead Sea is not quite dead. And the clue is in the startling pink playas of Owens Valley.

Return to the crusted pink salt flats, baking in the harsh desert sun, and bend down again to the red salt crust. Even when the lake appears dry, a layer of brine occurs beneath a salty crust. The brine beneath the salt is so concentrated and so alkaline that it dehydrates and burns your fingers, and yet, adapted to live in the brine itself, is a form of life: the extremophile *Halobacterium halobium*.

H. halobium are tiny rod-shaped bacteria, only five microns long and a half micron in diameter. They are members of the grouping known as archaea, once called archaeobacteria, but now recognized to comprise an entire subkingdom of their own, separate from the bacteria. Archaea are an ancient form of life that is believed to be representative of the original life that first colonized the Earth.

Halobacteria are tough. The intense desert sunlight does not destroy them. They live in salt solution so concentrated that crystals of sodium chloride precipitate out next to them. They are able to survive being desiccated into a crust of solid salt, returning to active life when water returns. They are capable of traveling distances of hundreds or even thousands of miles in the form of dry, windblown dust and salt, and will blow across the desert until they find another transient puddle of salt-saturated water.

Halobacteria are so strongly adapted to living in salt that they actually disintegrate in water with less than 12% salt—four times the salinity of ocean water.

The halobacteria photosynthesize, not with the common photosynthetic agent chlorophyll, but with a different pigment, bacteriorhodopsin, a purple pigment which is similar to the chemical that receives light in the retina of the human eye. Unlike plant photosynthesis, the halobacteria photosynthesis produces energy, but not oxygen. Another

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red pigment, bacterioruberin, protects the cells against the lethal effect of the blue and ultraviolet light. It is these pigments which give the halobacteria their bright red color.

Halobacteria have several relatives among the archaea. One relative, *deinococcus*, thrives in highly radioactive environments. Another relative lives in the snow of the south pole, thriving even in the polar ultraviolet environment, with metabolic activity continuing at temperatures of minus 12 to minus 17 °C

If any Earth life were perfectly adapted to live in the brines of Mars, it would be *Halobacteria halobium*. By living beneath a thin crust of salt, one of the most damaging aspects of the environment will be moderated, since chloride salts are opaque to short-wave ultraviolet radiation. (The most common salt, sodium chloride, has a short wavelength cut-off at 200 nm.) This will reduce the most damaging element of the vacuum—the ultraviolet radiation on Mars—while the bacterioruberin pigment will block the longer wavelength of ultraviolet radiation. Together, then; a salt crust and the UV-blocking pigment will prevent destruction of the halobacteria by the ultraviolet environment of Mars.

In Search Of

If we are to look for life on Mars, how and where do we look?

An initial objective for a science mission would be to verify whether transient occurrences of liquid water do, in fact, occur on Mars, and if so, at what locations. The results of Malin and Edgett support the transient outflow of liquid water at high-latitude locations; it would be useful to find whether lowland areas also have liquid water. A tool for such an investigation would be orbital radar. The high conductivity of brine solutions could make it possible not only to detect water with radar, but also to make an approximate measurement of the saline concentration. Since the liquid phase is likely to be transient, an orbital mission seeking liquid water will require a long duration and an orbit which visits the same sites repeatedly at different times of day, to elucidate the details of the water cycle.

It would also be of interest to search for life directly. Halobacteria have a distinctive spectral signature due to the photosynthetic pigment bacteriorhodopsin. It is rather unsupported speculation to expect that Mars bacteria would utilize an identical pigment, but nevertheless, it would be an interesting experiment to use hyperspectral imaging to search for the signature of halobacteria. In "hyperspectral" imaging, a camera is designed to take pictures in a dozen or more spectral bands, making an image where each individual pixel is a spectrogram. A computer can then compare the spectrum at each pixel with the spectrum of mineral samples, and turn the hyperspectral map into a compositional map. Hyperspectral imaging could focus particularly on the likely locations of low, flat areas that are likely salt beds to look for photosynthetic pigments. More likely to produce results would be a search for the spectral signature of salts, in order to identify "playa" locations where salt deposits would be located.

The speculation of possible extant life in the form of halobacteria on Mars lends some suggestions toward possible landing sites. If a landing mission is designed to search for halobacteria, the desired areas to search would be low salt flats and dry lake sites. Such sites are also desirable locations for other biological investigations, and several potential sites—such as the one in figure 2—have been identified on Mars.

The Andromeda Syndrome

If bacteria live on Mars, shouldn't we worry? If a bacteria can live in the harsh environment of Mars, wouldn't it be so tough that it would take over the Earth if it were brought to the warm, life-friend-

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ly environment of our planet?

Well, no.

Darwin's lesson is that life adapts to its environment. Life adapted to live in the cold, dry, saline, ultraviolet-rich environment of Mars would have no chance on Earth; it would simply be misadapted in every way. Bacteria of Earth have had billions of years to fine-tune their metabolisms to take advantages of the ecological niches of Earth; a bacterium that had never been exposed to warmth or oxygen or fresh water simply couldn't compete. Far from being robust on Earth, Mars life would be fragile beyond belief. If even *Halobacteria Halobium* cannot survive in salinity less than four times higher than the salinity of seawater, we are in no danger from them.

A Change of View

Thirty years ago, the Mariner probes took the first close-up pictures of Mars, and forever destroyed the science fiction dreams of a populated desert planet. The Viking missions seemed to confirm the view of the planet as a cold, dry desert with no life and, in the absence of liquid water, no possibility of life.

But the new possibility of liquid water, and halobacteria, changes that view.

Everything is different now. ■

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About the Author

Dr. Geoffrey A. Landis is familiar to *Analog* readers from his many stories. He works on advanced concepts for spaceflight and on designing power and propulsion systems for Mars missions at the NASA John Glenn Research Center in Cleveland, Ohio. He was a member of the Mars Pathfinder team (as recounted in the science fact article "Adventures in the Mars Business," *Analog*, July 1998) and is now designing instruments for future Mars missions. More information can be found on his web site, http://www.sff.net/people/geoffrey.landis. His first novel, *Mars Crossing*, appeared from Tor Books in December.

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Advanced technology may not change basic human interactions, but it does broaden the options. . . .

MY FAVORITE ROBOT

Ron Goulart

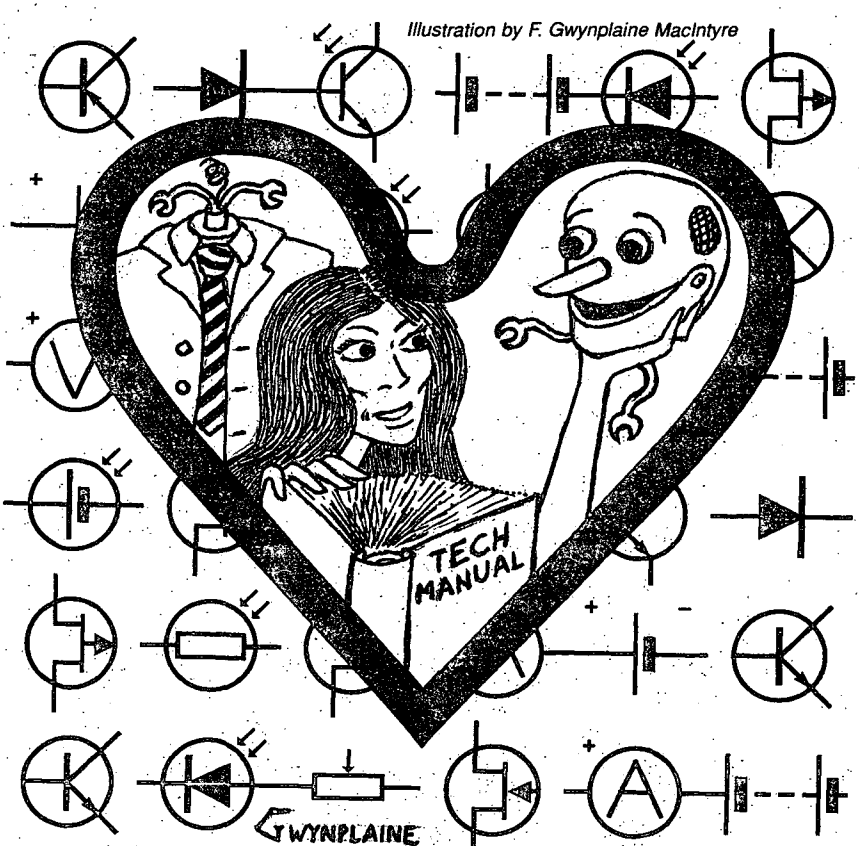

Illustration by F. Gwynplaine MacIntyre

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He sat up in the sturdy neowood packing case, creaking slightly, and blinked his chrome-plated eyelids. "So your minimalist conscience finally got the better of you," said the big, wide, silvery robot, "and you've brought me back from the dead, Maggie."

"Technically, Ben," pointed out Maggie Quincade, "you've never been *alive*. The Robot & Android Act of 2019 clearly states that a Guardbot isn't to be considered a living org—"

"You deactivated me on the sly, after implying you were going to look after me and—"

"A great big hulking bot with all sorts of built-in gadgets and weaponry doesn't need much looking after, dear," the slim, dark-haired young woman reminded. "I did, yes, take pity on you after your brainchip got accidentally installed into the skonce of a huge, ugly—"

"What the hell is that out there?" The robot had climbed, with considerable rattling and ratcheting, free of the crate and gone lumbering over to one of the viewindows of Maggie's beachfront condo in the Malibu Sector of Greater Los Angeles. "That stuff coming down through the late afternoon sky?"

"Snow, obviously." Bending from the waist, she picked up the few shreds of plyoselsior he'd shed on his clomping trip to the window.

"Snow? In SoCal?"

"It's something they introduced this year," she explained. "Artificial snow for the Xmas season."

He turned, slowly, his plaz eyes staring at her. "It was September when I was first delivered to you and we cleared up that Serv-U servomech business," he said, angry. "You've let me languish in that box for months?"

"I had a lot of things to take care of, Ben." She held up three fingers. "And, actually, it's only been three months. When I first decided to keep you, I was sort of euphoric, you know, because of how nicely we worked together. But then, once I got you back here to my place—"

"Technically it's *our* place. I'm your husband, remember?" The big chromed bot pointed an accusing finger at her. "It takes a very cold and heartless woman to sneak up on her husband, jab the control buttons concealed in his armpit and put him into a state of suspended animation that drags on week after weary week. I lay here in a stupor, a hopeless vegetable who—"

"You can't be a vegetable if you're made out of metal and stuffed with all sorts of electronic gear," Maggie pointed out. "And, really now, Ben, you are *not* my husband. You contain a brainchip copy of Ben Quincade's alleged mind and you speak in a fair imitation of his annoyingly nasal voice, but the real Ben—"

"Now that you mention it, yeah, where is the real me?"

"Brazil."

"What the hell am I doing in Brazil?"

"Quincade & Quincade Advertising opened an office there last month and you . . . and he . . . and the real Ben moved to Rio to run it," she answered. "We landed the Carmen Miranda Android account, so—"

"What's the state of our marriage?"

"The divorce will become final on April 13 of next year," she said.

"That's too bad, Mag, since you and I got along very well during my days out of the box and—"

"*You* are a robot," she reminded him. "You I can tolerate."

"Yeah, so long as I reside in a coffin, like Snow White or Dracula or Sleeping—"

"Sit down." Maggie nodded at the neohide sofa. "But carefully. I'll explain why I've brought you back to life."

"Ah," the robot said. "It wasn't guilt that prompted you to resurrect me. You have, which, I must mention, Mag, is typical of you, an ulterior motive."

"It'll bring our ad agency 18 percent of a $24,000,000 advertising account."

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As he settled himself into a seated position, the sofa produced several protesting *whang* noises. "You want me to help you work up a pitch to get us this new account?"

Maggie shook her head. "Nope. I want you to help me solve a murder," she said.

The tall, lean Advertising Manager let go of Maggie's hand, straightening up without kissing it as he'd intended. Stepping back from her, he frowned in the direction of the big robot. "Is something wrong with your mechanical man, Maggie?" he inquired as he took another step back.

Ben produced another rumbling noise inside his metallic chest. "I thought this was a business meeting," he said. "All this hugging and smooching is—"

"His jealousy mechanism needs tuning," put in Maggie, frowning at the robot. "But basically, Abner, he's as harmless as—"

"Harmless, my fanny," said the robot. "If you really thought I was harmless, I'd still be dreaming in my coffin and—"

"He's very outspoken, too. I'd have that adjusted as well." Abner Gullion crossed his large office in the North Tower of the Momz Homecookin' Building in the Hawthorne Sector of Greater LA. "But if he suits you, hon, it's—"

"How come this gink calls you hon?"

"Sit down, Ben, and behave." Maggie waited until the ad manager was seated behind his boomerang-shaped tin desk and then took one of the rubberoid chairs facing him.

Gullion asked, "Your robot has the same name as your late husband, Maggie?"

"Yes, although Ben isn't actually dead, Abner. Only in Brazil for an extended stay."

"It was my impression at dinner the other night you told me he was dead and done for."

The robot unbuttoned his overcoat, took off his beret and stuffed it into his pocket. He produced a loud thump when he sat in a rubberoid chair. "Pack me in a crate and then fool around with gawky hand-kissing ginks who—"

"Hush," she advised, reaching over to pat his metallic left hand. "Think rather about the $24,000,000."

Ben rumbled, more quietly, saying nothing. When he crossed his legs, it made a resounding bonging noise.

The Momz exec frowned. "Might I ask why your bot wears an overcoat and a hat, Maggie?" he asked.

"I'll explain later, Abner."

"Modesty," muttered Ben. "Decency."

Gullion glanced at his viewindow, watching the light snow falling down across the waning day. "I appreciate your offering to pitch in and help us here at Momz Homecookin' Worldwide with our little problem," he said, smiling, somewhat guardedly, at Maggie. "As you know, both the SoCal State Police and the private-investigating outfit Momz Homecookin' has hired have already concluded that we're in no way responsible for the killing." He paused, clearing his throat. "However, until the killer is arrested . . . well, a cloud's going to be hanging over the reputation of our organization."

"We've had some success, my Guardbot and I," Maggie told him, "with criminal investigations, Abner. So the moment I heard about this murder case, I said to myself, 'Maggie old girl, you and your big clever robot sidekick can sure as heck beat the cops and some pipsqueak private eyes to the solution of this baffling mystery.'"

"Maggie old girl," muttered Ben.

"Actually there's nothing especially baffling about it," the thin Advertising Manager assured her. "Everything points to the fact that Spence Kirkeby rigged the Momz McCracklin android to act the way it did. What we have to do now is simply track that disgruntled bastard to his lair and bring him to justice."

"We'll run him to ground," promised Maggie. "Ahead of the rest of them."

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"The tape from the secam." Ben uncrossed his chrome-plated legs and leaned forward. "Can we see that now?"

Gullion touched one of the control pads built into his desk top. "Look at the screen, folks," he invited.

One of the viewindows hummed for a few seconds, blanked and turned to a vidscreen. The large office dimmed its lights.

"This was taken by one of the security cameras at the Bestsellers Only Bookshop in West Hollywood Sector Underground Mall #3 two afternoons ago." He touched the control pad again.

A pleasant-faced, plump, grey-haired woman of sixty-some years was seated at a small floating table in an autographing nook at the chain bookshop. Just behind her a small portable printing unit was turning out bound copies of a book entitled *Momz McCracklin's Homecookin' Cookery Book.*

Each time a fresh copy popped out of the slot in the machine's front, the cozy woman would grab it, swiftly inscribe her name on the flyleaf and hand it to the next customer in the long line. "Here you are, dear friend, enjoy."

"That's not actually Momz McCracklin we're seeing," explained Gullion.

"I know," said Maggie, "which is why Kirkeby was able to arrange the murder."

"Momz herself, bless her heart, is resting up at the Betty Ford Orbiting Rehab Center just now. Been there for close to a week," the advertising executive told them. "The old darling is suffering from overwork and mild burnout. So, although we really don't like to fool our public, we substituted her andy simulacrum at the recent signings at the various Bestsellers Only shops. It's possible these days, as you no doubt know, to install a brainchip in a highly believable android and—"

"We know about that, yeah," said the robot.

A large, thickset man of about forty had come pushing to the front of the line. "Well, here I am, you old sow," he said loudly. "Why weren't you at—"

"Don't use that tone with me, Luther B. Barker." Momz reached into her jacket pocket and yanked out a lazgun.

The startled customers gasped, cried out and screamed as the grey-haired woman fired the gun and sent a sizzling beam of glaring yellow light at the intruder.

It caught Barker across the chest, slicing his body in two.

The tape ended as the dead man's upper torso hit the thermocarpeting and bounced once.

"That's awful," said Maggie quietly.

"Explain why everybody thinks," requested Ben, "that this Kirkeby guy had something to do with this business?"

"Well, like Luther B. Barker," said Gullion as the window unblanked and the lights came up, "Spence Kirkeby was a former employee of Momz Homecookin' Worldwide and he claimed his ideas had been stolen. He worked in our Test Kitchens and he actually did aid in the development of a very effective Pasta Chef andy that—"

"The idea, Ben," added Maggie, "is that Kirkeby rigged the android so that it would, in violation of one of the basic rules of robotics, shoot and kill Luther B. Barker."

Ben narrowed his plaz eyes. "And why would Kirkeby want to kill Barker?"

"After he was terminated here," picked up Gullion, "Kirkeby went to work for Barker over in the Anaheim Sector. Barker's Uncle Lute's Nearly Natural Pasta Factory has been a very lucrative operation."

"Kirkeby, true to form, had accused Barker of stealing his ideas for a new, improved Pesto Sauce machine," said Maggie. "All of this is in the dossier disc I gave you to read, Ben."

"Um," said the robot. "And why was Luther B. Barker pissed off at Momz McCracklin?"

"He maintained, quite wrongly, that he was the creator of Momz Apple Pie and that he'd never been sufficiently

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compensated," explained the advertising exec. "After his legal actions got him nowhere, Barker resorted to threats. Had he not been killed, we'd probably gone to the law to restrain him."

"What was the guy alluding to when he yelled at Momz?"

Gullion blinked. "Beg pardon?"

"Barker said, 'Well, here I am, you old sow. Why weren't you at—' I was curious as to how you and the cops and your private eyes interpret what he was trying to—"

"Here's how I interpret what *you're* saying, tinpants." The door of Gullion's private office had come flapping open, aided by a profound booted kick.

A five-foot-tall red-haired woman in her early thirties came striding into the room: She was wearing a sleeveless neohide jacket, white slax and crimson boots. Her gunbelt held both a lazgun and a stungun.

"Ah, Miss Pepper." Gullion, somewhat carefully, stood up and tried a smile. "What a pleasant surprise. Although, to be quite frank, I could've done without your booting my door nearly off its—"

"Up your snoot, jerkoff," suggested Betty Jo Pepper. "Let's get something straight, folks. Sunset Investigating Services has the exclusive contract to investigate the Barker murder case and get your company's butt off the grill." Scowling, she pointed at Maggie. "That means no slatternly advertising floozies and their animated junkyards can go sticking their beezers into—"

"Leave." Ben had risen up out of his chair.

"Take a hike." The angry private eye stomped closer to Maggie. "As for you, bimbo, pack up your—"

"Depart," suggested Ben. "You're intruding on a private meeting, Miss Pepper."

"Nertz," she replied, reaching for her stungun.

Ben sighed and shot a stunner beam from his metallic forefinger.

It hit the young woman in her midsection. She murmured "Oof," folded some, and dropped to her knees. After swaying for a few seconds and then tipping over, she stretched out on the floor, unconscious.

Later, as the two of them were descending in an elevator, Maggie remarked, "I think Abner was very impressed by the way you handled that intrusion by that awful lady gumshoe."

"I intended him to be."

"We've got a great chance of getting the Momz account now," she said, smiling. "All we really have to do is track down that guy who rigged the Momz McCracklin android to commit murder."

"That's not going to do us a heck of a lot of good, Mag."

Frowning, she asked, "Why not?"

"Because that wasn't an android who did the killing," he answered.

The waiter at Senhor Legume's, a Portuguese vegetarian bistro in the Santa Monica Sector that had been a favorite of theirs during the earlier and happier phase of their marriage, was a very believable android. And though he couldn't actually speak Portuguese, his Portuguese accent was quite convincing.

"Ah, so nice to see you again so soon, Senhora Quincade," he said as he approached them across the dimlit foyer of the restaurant.

"Same here, José," Maggie said. "We'd like a table near the viewindow if possible."

Smoothing his moustache, José glanced at Ben. "Wouldn't your robot rather wait in the car?"

"No," said the robot.

"He's a sort of bodyguard," she explained.

"Well, would he at least like to check his coat?"

"He suffers from chills," Maggie said. "The table, José?"

After a few seconds the android said, "Right this way."

When they were seated at a small round table overlooking the night sea,

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Maggie suggested, "Take off your darn beret, Ben."

"Sorry." He snatched it off, tucked it away in a pocket. "I didn't realize there was so much prejudice against robots in SoCal."

"Since robots don't eat, you can't expect restaurants to take much interest in catering to them."

"I don't eat, true, but I'm good company."

"Everybody doesn't notice that immediately," Maggie told him. "It even took me a bit to realize just how charming you were in this new format." Leaning, she rested her elbows on the table top. "Now, please, go over this theory of yours again."

"I explained it all in the skycar coming over here," he said. "Oh, and by the way, how come you were dining here recently? This was, I thought, *our* place."

"I had dinner with Abner here a week or so ago," she admitted. "Purely a business dinner. I want our agency to get that darn Momz account, Ben. Besides which, even though your robot self and I are sort of a team . . . well, your human self and I have ceased to be an item. Therefore, I see no need to hold our former haunts as sacred. Okay?"

"Forgive me for being sentimental. It's only that you and I used to come to Senhor Legume's so often in the old—"

"No, nope. *You* have never been here before," she reminded him. "Now, c'mon, I want to hear again why you suspect that it wasn't an android sim of Momz McCracklin we saw doing the killing."

"I don't suspect, Mag, I *know*," he answered. "It's a capability I have built into me, now that I'm a Guardbot. I can *sense* an andy—and that wasn't one."

"Meaning you have this dippy theory that it was actually Momz McCracklin who knocked off Luther B. Barker?"

The silvery robot said, "I don't know if that was truly the one and only Momz we saw slice up her disgruntled competitor or not, *but* that was definitely a human being wielding that lazgun, Maggie dear."

Her face took on a sour expression. "That is really going to futz up our chances of getting the Momz account," she observed. "I mean, if we prove the old dear killed Barker, they're not very likely to be too cheerful or—"

"Integrity and honesty can be a handicap."

"Hey, Ben, I'm not saying we shouldn't pursue this," she said. "But if it turns out that was really Momz and not just somebody impersonating her . . ." She trailed off, sighed, and then gazed out at the dark Pacific.

Three neon-trimmed sailboats were gliding by.

"It could well be that wasn't the real Momz," he conceded. "We have to get our own copy of that security tape—as well as any others that Bestsellers Only shop has."

"You can tell if it's actually her?"

"Sure, there are ways to scrutinize—"

"Evening, folks." A heavyset black man in a two-piece lime-green cazsuit had materialized in the third chair at their table. Part of his left side appeared to be imbedded in the table top.

"Adjust your holoprojector," advised Ben. "It looks like you're fused with our table."

"That's OK, I'm only going to be here a few minutes."

"Even so. It's an unpleasant sight."

"OK, OK, don't get your gears in an uproar," said the black man. "Vince, about a foot to my left."

A small boy at the next table asked his mother, "Who's that man?"

"Probably a cop," she said. "They're always and forever pulling holographic invasions of privacy. It's a wonder we don't have flatfoot images all over our homes and—"

"Be thankful, lady, that the SoCal State Police are so alert and efficient," the projected policeman said over his shoulder.

"Is he going to arrest that bot, Mom?"

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"He'd probably arrest us all if he had his way."

Maggie asked the image, "Why exactly have you barged in on our dinner?"

From his breast pocket he took an ID packet. "I'm Lt. Brattigan of the SoCal Homicide Bureau," he said, showing his badge and tri-op identification card. "I dropped by to hand out some friendly advice, Mrs. Quincade."

"Do you," asked Ben, "have an Intrusion Permit, Lieutenant?"

"Sure," answered Brattigan. "Is it true, as I've been led to believe, that you two amateur sleuths are poking your snoots into the Kirkeby case?"

"How come you call it the Kirkeby case?" asked Maggie. "There's no real evidence that Spence Kirkeby had a darn thing to do with the—"

"No real evidence that you know about, sis," said the policeman. "But, being an amateur, there's a whole lot you aren't aware of."

Ben asked, "Have you arrested Kirkeby?"

"Not yet, but we're damn close to finding the guy," he said. "Anyway, I'm here to suggest that the SoCal State Police would be happy if you dropped the whole thing."

"Or?" asked the robot, resting one big metallic fist on the table-top.

"Wait, now, big fellow, I'm not threatening either of you in any way," the cop assured him. "All I'm saying is that we'd be happier if you simply stopped playing detective."

"We appreciate your friendly warning, Lieutenant," said Maggie, smiling sweetly at the image. "We'll certainly give what you've said some serious consideration, you can bet. Now can I order my dinner?"

Brattigan returned the smile and vanished.

"How'd this guy know about us?" asked Maggie, watching the spot where the policeman had been.

"Either your pal Abner told him or Betty Jo Pepper did," suggested the robot.

"Then maybe they're all in cahoots."

"Maybe," he agreed.

Santa Claus laughed. "It's the Xmas Season, folks," he announced in his deep, jolly voice. "You can shop around the clock here at SeaMall!"

The android St. Nick was stationed just outside the arched entryway to the vast SeaMall complex, a multidomed structure that rested on stilts out over the Pacific Ocean in the Santa Monica Sector.

"Why, exactly," Maggie inquired of the robot, "are we stopping here?"

"I want to consult an informant," he answered, taking her by the arm and escorting her across the threshold.

Seasonal music, spilling out of dozens of floating speakers high overhead, surrounded them. Android and robot pitchmen spieled.

"How come," she asked, raising her voice, "you know there's an informant here? Do Guardbots come with a built-in list of stool pigeons, infotappers and—"

"This is someone I used now and then back when I was myself."

"Oh, so? And why did you need a—"

"Mrs. Molesworth is very good at digging up background material," the robot said. "C'mon, we want Ramp 6, over yonder next to the Bestsellers Only outlet."

Five ragged Victorian urchins were huddled to the left of the bookstore entrance, low-cost androids who sang a seasonal carol in slightly offkey voices. They stood ankle-deep in a patch of plaz snow.

"Why were you in the need of background material—and on whom?"

"Prospective clients mostly," he answered, stepping with a heavy thunk onto the upmoving ramp.

"You never told me about that. Seems to me if you were spying on our business associates, you should've, if you were actually the sort of upright and honest fellow you claimed to—"

"I kept us from being swindled and

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conned, especially by those overly handsome ad executives you were continually flirting with and sneaking off to have intimate dinners with at quaint little bistros that I, being less crass and far more sentimental, had thought were special and for us only."

Frowning, Maggie shrugged free of his grasp. "For a husband who philandered around the clock, Benjamin, you sure weren't in a position to criticize me for merely attempting to keep our agency afloat amidst—"

"Oswald Bierhorst."

"Hum?"

"Oswald Bierhorst, the advertising manager of Sweatshops International."

"Oh, that Oswald Bierhorst. What about him?"

"He's the one you . . ." The robot's wide metallic chest rattled slightly as he gave a forlorn sigh. "Never mind, it really doesn't matter now."

"Hey, are you implying, in your usual clumsy way, that I fooled around with a gink like Oswald Bierhorst?" She poked him in the side with a clenched fist, producing a steel drum bonging. "You don't seriously think that I'd fiddle around with a man who is only five foot two and weighs in at 226 flabby pounds? I'd sooner—"

"Love knows no boundaries, they say. Here's where we're going."

On their right was a shop built to resemble a thatched cottage. Floating above its doorway was a throbbing litesign proclaiming—*Old Stuff, Inc—Your Best Source of Faux Nostalgia!* Screwed to the door itself was a small neobrass plaque that stated *Mrs. Molesworth, Proprietor.*

Stopping on the fuzzy doormat, Maggie said, "Is Mrs. Molesworth the one who fed you those lies about me and the abominable Oswald Bierhorst?"

"We have to keep the problems of our personal life from interfering with our business, Mag," he cautioned. "We're involved, I'm very much afraid, in a very dangerous case."

"You don't *have* a personal life," she told him. "You're a robot."

"I wish," said Ben, opening the shop door, "you'd quit harping on that."

Mrs. Molesworth sneezed again. "It's that damn imitation Xmas snow," she said, dabbing at her nose with a plyochief. "I'm allergic to the stuff, especially the flakes that come in pastel shades. They're using some kind of genetically modified vegetable dyes in the—"

"About the information you were supposed to dig up for me," cut in the robot.

She was a plump woman in her late fifties, platinum blonde and decked out in a floral pattern bizsuit. Smiling sympathetically at Maggie, Mrs. Molesworth said, "I see he's still a pain in the toke in his new format, hon."

Nodding, Maggie said, "Actually, he's somewhat more tolerable as a robot."

"Well, somewhat maybe," the hefty woman conceded as she rose up out of her aluminum swivel chair.

The small office was cluttered with believable replicas of last century artifacts that hadn't yet made it out into the main sales room of the shop. Among the sprawl of stuff were a large Raggedy Ann doll, a Flexible Flyer sled, three Flash Gordon Big Little Books, a copy of *Detective Comics* #27, a shoulder-high plastic juke box, a stack of 33 1/3 LP records, a carton of Lucky Strike cigarettes and a framed photograph of Carmen Miranda.

Pointing at the picture, Maggie tapped Ben's knee. "See, I told you she was popular again."

"In Brazil maybe, but—"

"Take a gander at Screen #3," invited Mrs. Molesworth. She was standing near the far wall, chubby fingers pushing at a control pad. At her booted feet lay several faux teddy bears.

Part of the neostucco wall slid aside, revealing a bank of six view screens. "After you phoned me, Ben, I got to work

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on—"

"When did you call her?" Maggie asked the robot.

"I can do that internally, which is how come you didn't notice."

"You mean you've got a phone built into your innards?"

"Also a fax and a CD player."

Maggie gave a mild, brief shudder. "That sounds kind of uncomfortable. I know I wouldn't want all that junk inside my—"

"Being a robot isn't noted for its comfort," he replied. "I, of course, didn't have much choice, since my brain was dumped into this clunky—"

"It's a brain chip, Ben, not an actual brain. That's still in your . . . in his head."

"Hey, can you kids carry on your lovers' quarrel later?" asked Mrs. Molesworth, impatiently. "I've got a business to run."

The robot said, "OK, what did you find out about Momz McCracklin's activities during the days in question?"

"Look, as I believe I mentioned earlier, at Screen #3."

What they saw was Momz McCracklin, carrying a neohyde attaché case, hurrying up a ramp to board a private space shuttle. The *Momz Homecookin'* logo was etched on the side of the silvery craft.

"She's embarking for the Betty Ford Orbiting Rehab Center," explained Mrs. Molesworth, "in one of the company ships. This beguiling footage I was able to acquire from the Woodland Hills Sector Spacefield secams."

"That's really her?" Maggie asked.

Ben said, "Yep, it's not an andy."

"Not an impersonator either," added the plump information vendor. "I did an ID scan."

"What was the date?" asked the robot.

"She left Greater LA the day *after* Luther B. Barker was gunned down at the Bestsellers Only shop in the West Hollywood Sector."

Maggie said, "Then she wasn't up there when the murder took place."

"Nope, not at all," said Mrs. Molesworth. "I was also able to siphon some electronic information that proves the admissions records up at Betty Ford were fudged to make it seem the old girl hit the joint a few days earlier than she actually did."

"Darn," muttered Maggie.

"Exactly," agreed the big robot.

"It's starting to look like the real Momz did bump off Barker," the young woman said ruefully. "We're going to have a heck of a time landing that account after we put Momz away for murder."

"We have to do it, Maggie," said Ben. "There's a certain responsibility that goes with being detectives."

"Have you kids considered blackmail?" Mrs. Molesworth reseated herself in the metallic swivel.

Maggie narrowed one eye, rubbed at her chin. "That might be one way to—"

"No, nope, not at all," cut in the robot.

Slumping some in her chair, Maggie said, in a small disappointed voice, "Yeah, I suppose we can't do that. We'll just have to keep investigating and hope for the best."

"You want me to keep digging on this?" inquired the plump woman.

"Did you get anything else from that list I faxed you?"

"Working on it," she answered. "Oh, and if you want anything on the inner workings of the Momz Homecookin' operation, I'm chummy with Patch McCracklin, her son. He collects real nostalgia stuff, loans me some of the originals that I copy. A nice boy."

"If I could still eat, I'd like their secret carob chip cookie recipe." Rattling some, the robot rose up. "We'll be in touch."

Mrs. Molesworth smiled at Maggie. "You know, hon, I think he *is* a lot nicer as a bot."

"I suppose, although he might be a shade too honest," she said.

* * *

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When Ben pressed his metallic forefinger to his metallic lips, it produced a small *pang* sound.

They'd just crossed the threshold of Maggie's seaside condo and after the big robot turned back toward her, she said, "What's the matter now?"

"Silence," he urged in a tinny whisper. "Do not speak."

Giving a resigned shrug, Maggie said nothing.

Ben, slightly hunched, began a slow circuit of the living room. He swept the palm of his right hand over the furniture, the carpeting, the walls. While his hand hovered over a framed holoshot of Maggie's parents, his thumb began to glow a pale orange.

Carefully, he pulled the picture free of its magmooring pad and examined its backside. A small circle of grey plaz was affixed there.

The robot pointed his middle finger at the bug, a beam of yellow light shot forth. Nodding, he plucked the disc free,

"Who's been bugging my darn—"

"Continue to maintain silence," advised Ben.

He checked the rest of the condo, finding a small black bugging cube concealed in the thermo oven.

Finally, sighing, he thumped down on the rubberoid loveseat. "In answer to your earlier question, Mag," he said, "I'd venture to say that, firstly, Lt. Brattigan of the SoCal State Police arranged to have this place bugged. That was a SCSP type of spy disc I found attached to the picture of your ungainly parents and—"

"My folks are quite presentable, unlike those unkempt nitwits who foisted you on the world. I might also mention that—"

"The spy device planted in the kitchen is of the sort used by the Sunset Investigation Services outfit, employers of the formidable Betty Jo Pepper," continued Ben. "Meaning that both cops and private eyes continue to be interested in our activities."

Maggie commenced pacing in a circular pattern. "First they attempt to warn us off, then they try to spy on us," she said. "Why are they so interested in us?"

"Maybe they're all devoted to framing Spence Kirkeby for the murder," suggested the robot. "And we might spoil that with our nosing around."

"What would their motive be for that?"

"It's possible, since Momz herself is a likely suspect, that some employee of Momz Homecookin' offered all of them substantial bribes to divert suspicion from the dear lady," said Ben. "Might be that your beau, Abner Gullion, is the very lunk who—"

"Abner is no romantic interest of mine, dodo. Simply because I have an innocent business meal with the guy doesn't mean we're having a torrid affair."

"You took him to one of *our* places. That sounds romantic to me."

"What say we get back to—"

"Something's going on wrong," warned Ben, popping to his feet and pointing toward the door to the condo.

The door suddenly turned to shimmering dust and a bright beam of purple light came shooting in, slamming into the robot's wide silvery chest.

The windows to his right, all five of them, were oval and offered Ben views of underwater life. Mostly what the robot saw as he awakened was the murky waters of the Pacific, dotted with genetically-improved marine life that had been designed to survive amidst the contamination while remaining decorative and edible.

He was sprawled on his back on a neohyde sofa. Checking with his various inner workings, he found that a stungun, a disabler and a brainchip eraser had been used on him.

"Or at least they tried," he said to himself. "But I'm no ordinary robot."

The stungun had worked, knocking him out for, so his internal clock informed him, a few minutes less than

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four hours. But ever since his most recent resurrection, and while collaborating with Maggie, Ben had been working at modifying himself. The disabler, therefore, had failed to affect him and the defenses he'd set up to protect his memory files and his brain had turned out to be as effective as he'd anticipated.

"But where the hell am I?" he said aloud, sitting up with considerable ratcheting and rattling. "And what's become of Maggie?"

"I'm afraid they've got her, hon."

Turning his metallic head, Ben saw Mrs. Molesworth sitting in a tin rocker near the arched doorway of the underwater parlor. "They being who? And me being where? And you might also fill me in on how and why."

The plump platinum blonde stood, causing the rocking chair to flap back and forth a few times. "They consists of a conglomeration that includes Abner Gullion, the petite PI Betty Jo Pepper and assorted minions of the law, including Lt. Brattigan of the SoCal State Police."

"Plus Momz McCracklin?"

Mrs. Molesworth said, "She's involved, but at a distance. And we're in a hideaway of mine in the SubMarina Estates underwater condo complex off the coast of the Laguna Sector."

"How'd you come to convey me here?"

"Turns out my security systems weren't as foolproof as I believed," the information merchant admitted, briefly chagrined. "Some scoundrels from the Sunset gumshoe outfit got wise to my probing on your behalf and were getting ready to converge on my Old Stuff, Inc place of business. When I got wind of this, I decided to relocate for a spell." She settled into her chair again. "I also, kindly soul that I am, took the time to drop by at dear Maggie's joint to warn you kids that they knew we were aware of Momz' probable involvement in the killing."

"But you got there after we'd been visited."

"Alas, yeah, hon." She said forlornly. "Maggie they hauled off and, I fear, are planning to use a limited brainwipe on. That's mostly because Abner Gullion's sweet on your missus and figures if they take away all her memory, she won't remember who he is. She'll simply forget all about the Barker murder case."

"Where have they taken her?"

"I did some very careful nosing around from here while you were snoozing, and determined that she's up there. At the orbiting Betty Ford." She aimed a fat thumb at the ceiling. "How come, by the way, they left you behind with your memory intact?"

"They thought they'd futzed my brain, but I'm not an ordinary robot," he replied, rising to his feet with a couple of thunks. "Can you get in touch with your chum Patch McCracklin and set up a meeting?"

"I can, but why do you want Patch?"

The robot tapped the side of his head, producing a few *bonk* noises. "It fits in with my plan for rescuing Maggie," he said.

"When's the last time you were burnished, old man?" inquired Patch McCracklin.

Ben said, "Let's concentrate on our mission."

"I'm not being critical, mind you. Merely stating my opinion that you'll make a better impression if your surface sparkles."

The robot was standing near one of the portholes in the lounge of the private shuttle. He'd shed his overcoat and was getting into a crisp white medical jacket.

"That's a bit snug across the shoulders, old chap," mentioned Patch. A middle-sized pudgy man of thirty-five, he was wearing a 3-piece yellow cazsuit.

"How come you have a British accent?"

"Educated at Oxford, don't you know."

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"Nope, you actually attended the University of California, Woodland Hills Sector Campus. And you were tossed out of there in your sophomore year."

Sitting up in the tin chair he'd been slouched in, Patch asked, "How'd you come to know that, old man?"

"I had you researched," replied the robot. "I also found out that you and your aunt aren't especially close, but that she's hoping you'll change enough to be able to take a larger part in running Momz Homecookin' eventually."

"I say, you've been deuced nosey in—"

"Furthermore, in a very sneaky and unobtrusive way, you've been exploring the possibility of taking over the Momz operation and tossing your aunt out."

Patch stood up, angry. "See here, old man, I've half a mind to turn this blooming shuttle around," he said. "When you and dear Mrs. Molesworth informed me that Maggie Quincade was a prisoner up at Betty Ford, I agreed to accompany you to the bally place to help free her. But I do believe you're going too far when—"

"I picked you, Patch, because, as a close relative, you can get us into the place," Ben said. "And because of your ambitions. After we rescue Maggie, we'll see about getting Momz McCracklin sent up for murder."

Patch sat down. "So the old girl did knock off Baker, eh?" he said, one eye narrowing. "With Momz in a Rehab Prison for a spell, I'll have a much easier time taking over the blooming Homecookin' operation."

"Exactly," said the robot. "Now let's go over what you have to do once we dock."

The plump, greyhaired woman smiled. "Why, how thoughtful of you, Patch, to come up to this satellite to visit your ailing aunt," she said. "But why the robot?"

"As I explained to the android blighter at the reception desk, Momz, he's my personal medical bot," said her nephew. "I brought the chap along in case you might, old girl, want a second opinion about your—"

"I'm afraid, Patch dear, I'm quite content with the staff here and have all sorts of confidence in them."

Ben moved further into the parlor of the suite of the orbiting facility. "Actually, ma'am, I'm here to collect my wife," he explained. "You and your crew of thugs have—"

"Whatever is this mechanism babbling about?" Momz rocked angrily in her rubberoid rocker, frowning at her nephew.

"It seems, auntie, that—"

"Get out of firing range, Momz. I'll handle this pile of scrap."

A door at the far side of the parlor had been booted open. The diminutive Betty Jo Pepper came charging in, lazgun in hand.

The robot dived behind Momz McCracklin's chair.

Giving it a substantial nudge with his broad metal shoulder, he sent the rubberoid rocker and Momz slamming into the red-haired private eye.

The chair flipped forward, tossing Momz smack into Betty Jo Pepper. That caused the detective to go stumbling backward until she sat, with a thump, hard on the floor. Her gun went spinning free of her grasp.

Ben, meantime, had dived to his left, squatted and aimed one of his stungun fingers at Betty Jo Pepper.

The stun beam hit her in the ribs. She slumped from a sitting position to a supine sprawl.

Sprinting forward, the robot caught up the fallen Momz under her arms.

"You scoundrel," she said, trying to smack him on his wide silvery chest.

"You're absolutely right." Holding her in front of him, Ben moved toward the doorway that Betty Jo Pepper had recently come bursting through.

In the sitting room beyond were Abner Gullion, a hologram of Lt. Brattigan,

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and Maggie, gagged with plyotape and tied with neorope in a tin chair.

"You folks have been behaving very badly," the robot told them. "And you, Brattigan, are missing your right leg from the knee down."

"We're getting new projectors in the spring. And you are going to be in a stewpot of trouble if you—"

"As I see it, Momz set this all up with your help," said the robot. "She pretended to arrange a meeting at the book signing with Barker to settle things. When he came barging in, she bumped the guy off. She'd already worked out a plan to make it look like it was an andy that—"

"We know all that," cut in Gullion. 'The thing is, we ought to be able to work this out. You people want the Momz Homecookin' account and we—"

"I'll be damned," cut in Momz, "if I'll let this floozie and her robotic gigolo advertise my—"

"Relax, old girl," suggested Patch.

"Everybody's going to jail," the robot assured them, setting the angry Momz down finally and taking a step back. "What you've—"

"Mmmm," said the gagged Maggie.

"I'll remove that gag." Gullion stepped over and yanked it off.

Maggie coughed, wiped at her lips with the back of her hand, winced. "Ben, let's see if we can't negotiate with these folks."

"These folks," reminded Ben, "happen to have committed murder, kidnapping and were contemplating giving you a mindwipe."

"I know, yes," she conceded. "Still, we're in a good position, thanks to you, to have a chat with them."

After a few seconds the robot nodded. "OK," he said, "chat."

Standing at one of the viewindows in the condo living room, the big robot said, "And what's that stuff?"

"Hail," answered Maggie from one of the neocanvas chairs.

"What's it commemorating?"

"Nothing. That's real hail."

"Ah, I was wondering why there weren't any pastels." He turned away from the stormy afternoon.

"You've been, even for you, extremely glum and moody in the three days since we've been back," she observed. "After all, you saved me from any serious damage, justice has been done and everything turned out pretty much OK."

"Justice wasn't done, Mag."

Maggie sighed. "OK, all right, admittedly Momz McCracklin won't be charged with murder," she said. "But, on the other hand, nobody's going to frame Spence Kirkeby. He's free and clear."

"Since he was completely innocent, that's—"

"Furthermore, Momz is stepping down as the head of Momz Homecookin' and she's checking into a private rehab center. They're allowing Patch McCracklin to take control, with some help from Abner Gullion."

"The same Abner Gullion who was going to let them tamper with your seemingly peanut-sized brain."

"Ben, I'm not saying it's a perfect resolution. But keep in mind that—"

"Yeah, that our ad agency will now be handling the Momz Homecookin' account."

Maggie rose up from her chair. "Hey, that's why I reactivated you, remember?" she said. "Which reminds me, I've decided not to deactivate you any more, Ben. You're quite a bit too moralistic—which is strange, since you're supposed to have the same brain as Ben Quincade—but you're a very handy fellow to have around."

"Thanks, I appreciate the gesture." The robot clunked over to the window again. "Although I guess I ought to mention that I've modified myself and you couldn't deactivate me even if you wanted to." ■

(EDITOR'S NOTE: Maggie and Ben appeared earlier in "I Married A Robot" [November 1999].)

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Wound the Wind

George Zebrowski

Near a fine line—like that between helping and meddling—it's often hard to tell which side you're on.

Illustration by Wolf Read

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"Don't part with your illusions. When they are gone, you may still exist, but you have ceased to live."

—Mark Twain

The dry veldt was a guilty patch on the planet, and no one went there much. Small plots of forest broke it up here and there, making cooler places of shade and water. Beasts went there to avoid the blinding sun.

We lay on our stomachs, looking over the top of a sandy, shallow rise. "From here," I told O'Connor, my team recruit, "we're sure to see the main group."

"Why sure?" he asked, peering through the shimmering heat, face shadowed by the wide brim of his hat.

"Because they've been in their plot of forest a long time now, living off the wildlife. They have to move."

"Quite right," he said, then was quiet for a while, reluctant to say whatever he wanted to say to me, as if the heat were trying to squeeze an unwelcome thought out of him. I felt his rivalry with me, but he seemed only distantly aware of his feelings.

"Why bother," he said finally. "They don't want our help. Never did."

There were such pockets left all over the world, of people who still didn't want to live on beyond the old human life-spans, as we did, making up our lives as we went along as we tried to mold the indefinite futures. It was hard for the majority to which I now belonged to see why these backwards hid from us, why they didn't greet us with open arms.

"They don't want us," O'Connor said again, this time with a hint of reproach in his voice.

"Then why are you here?" I asked, thinking of the strange missionary I had become, bringing the gospel of longlife back to the nature dwellers.

"No . . . why are you here?" he mumbled, hiding under his hat. "You've been at this longer than I have."

I knew why. I had always known why. "It may trouble you to understand," I said, "but their existence still tells us who we are. It makes us think about who they are, and why they are here, and why we have left them behind."

He squinted at me from under his brim. "And that's your reason?"

"One of them. There is strength in these people that we should not lose."

"Pretty abstract. I thought that somehow . . . you cared, emotionally, I mean."

"I do."

"I don't see the care in your face," he said.

"They're like us, as most of us were not so long ago. Still more like us than not."

I looked out across the veldt to the forest that sat halfway to the horizon as if it had been driven to clump there by the arid emptiness of the plain. Behind his show of detachment, O'Connor probably cared too much, or too little. I couldn't tell which. Like most of us, he had too much life ahead of him to be disturbed by anything near-term.

And then we saw them, the largest group of old humanity that I had ever spotted, moving out of the trees and across the blazing Sunday afternoon like a single beast with a hundred heads. Their weakest were in the middle of the body, where they could be helped along by the stronger.

"It's not like they don't know about us," O'Connor said. "They know and don't want us."

"They don't really know any better," I said, remembering. "They don't really see us."

"Think so?" he asked with a laugh. "If they did, they wouldn't want to live out here like this, would they?"

I was thinking that hunting down these people was useless, that we had gotten hot and dusty all for nothing, in the season when it got hot and dry and the sun hammered the land and made you sure to keep your hat on your head.

"Don't worry," he said. "I'll do my job, if only to see how it goes."

"It's up to us how it goes," I said as I

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watched the lumbering hundred-headed beast, "whether they live or die, whether we let them live or die out. It'll be up to us. Remember that."

"So it's about all the rest of us," he said grimly. "Not about them at all."

"Since we can choose and they can't, yes, it's about us."

"But will they all perish if we leave them alone? Is that so sure?"

I said, "The falling numbers show it—so it's up to us to prevent it. If we don't, then we will let it happen. And there's just enough of us willing to prevent it."

The beast with two hundred legs was well out in the open now. It looked like a ship of some kind, legs like oars rowing through a sea of dust, obscuring the long-haired heads of the passengers. Some were dressed in scavenged shirts and pants, sandaled feet and bare. Most carried knives of one kind or another, some a spike or spear. The wind was toward us, hitting us with the smell of sweat and hot animal skins.

"But can we help them?" he asked. "Seems that anything we do will be no good, or do harm. I don't think many people will sit around feeling guilty when . . . these are gone." It troubled him to say it. He could still go either way, and maybe take me with him.

I said, "We still have a voice, some of us. You and I are here, right now." But I was a bit puzzled by what was going on inside me.

He was silent for a moment, then he said, "What about this bunch?"

"We're going to catch up with this group," I said, "—and talk to them, for starters."

He smiled under the shadow of his wide brim, and his face showed only that smile. "What if we have to defend ourselves?"

"Maybe not with these," I said.

"Then you know more than I do."

"If we can talk to . . . this leader . . . in a certain way, then maybe we can . . . make it go easier for them."

"He's been scouted?"

"Yes," I said. "It'll take them a while to reach that patch of forest over there. We'll wait there for them."

We got up from our vantage point, made our way to our flitters, went up in silence and came down on the far side of the forest. Our vehicles were silent and fast, but we were not trying to hide our presence. We parked them at the edge of the trees, took our backpacks, and entered the patch. Halfway in, we found a small clearing, made a campsite, and waited for the group to arrive.

O'Connor said little during the rest of the afternoon, but I felt that he was working himself up to provoke me in some way that would ease his mind, or help him in some way that I would understand only if I let him provoke me. His very presence wore away at me, probed me, made me uncomfortable. He was irritating me with his repetition of my old mental motions, as he prowled down paths that I had worn away some time ago. He made them raw again for me. But I knew that he had to live with himself, one way or another. He was well aware of what could go wrong, what had gone wrong with contacting unchanged human beings.

At twilight we lit a fire from the wood we had gathered. It was blazing away by nightfall. The silence between us continued to unsettle me, but it gave me time to think things through from scratch.

"Again," O'Connor said, "why not just leave them alone?"

"Because so much human variety died in this century. We are responsible for these bands, for what will happen to them if we don't draw them out and raise them up."

"But if they refuse," he started to say, as if he didn't know the drill.

"Even letting them think that way is our fault," I said, "because we can change their life. They can't do it themselves. At best they achieve a static equilibrium with the wilderness. It's a prison to them, however much they feel part of it."

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It was all in the skin, I reminded myself, the sun and wind on your skin that made you feel at home. It wasn't a prison when it was your skin. It was a mother's embrace—when you weren't starving.

He sighed. "Maybe there are no good solutions for these remnants, or any kinds of answers."

"Perhaps so," I said, "but how we treat them says what we are. We have to try."

"So you don't think it's a lost cause, do you?" he asked. "You think there is an answer, even if it's only to make us feel better for trying."

I said, "It's never a lost cause. We must never let it become a lost cause." Yet I knew that there were problems that might have no solutions. Not now, or ever. Even with a remedy in hand, one might feel wrong about it, for no good reason.

He sighed. "Well, there's enough wilderness to leave them alone in. We've seen to that."

We waited until we saw the tribe creep in through the trees toward us. Silently, they sat down in a wide circle around our fire, well back in the trees, and watched us. A slight shift in the breeze brought their smells to us. I began to distinguish faces in the firelight, until one old man became distinct. Two younger men sat at his left and right, two others in back of him, and two in front. The few women all sat in the back, treasured guardians of the tribe's future.

I looked at his bearded face, and saw him watching me unblinkingly, as if he had fallen asleep with eyes wide open.

"What are they doing?" whispered O'Connor.

"It's pride," I said. "They want to see how long we'll tolerate their presence, their silence, before we begin to talk."

"Pride?" he asked.

We sat there for over an hour. Finally, the old man said, "You've been following us for some time. Why?" He spoke perfectly, as if he had just stepped up to lecture at a university, to ask his students what they were doing here, following in the footsteps of the truly learned.

"Quiet," I whispered to O'Connor.

The old man smiled. "My hearing is acute, son. If you have something to tell us, please do so. Have you brought some bad news?"

"No, there's no bad news," I started to say.

The world was filled with fewer and better human beings, able to live with the planet's violence.

"What do you want from us?" the old man asked, making it sound like a crime, and I felt the weight of dismay before insoluble problems. It was all about how we would live with each other after the last of these wretches died out. I knew the answer, of course. We would lament their passing, until we lived to forget that we had once imagined a solution. And that would be the end of listening to the past.

But for now I was here, set on doing something.

"You're afraid," the old man said, "that we will die."

"Yes," I said.

"Our children will replace us," he said as if it had already happened, but all I could see was the cloud of dust his band had stirred across the veldt.

I said, "We fear that all will die, that none will survive."

There were not enough of them for a viable population, but I knew that if I explained that to him it would only sound like a challenge.

"Don't you want our help?" O'Connor blurted out.

There was a long silence. Then the old man smiled. "I've seen enough of your world, with its beautiful people who know nothing of nature's true face, nothing of their own true face, nothing of reality."

"Reality?" O'Connor asked derisively. "One wouldn't want to face what you call reality."

He was right, I thought. We had come out of an cauldron, an evolving slaughterhouse that Darwin himself had dis-

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liked even as he had ferreted out and described its mechanism. It was no wonder that religious visionaries had sought to escape the life given to us through deluded imaginings. We had more than that now, yet we worried about the demise of tribes like this one. O'Connor's reaction to the old man had shaken me, because I saw through both O'Connor's eyes and those of the old man, and once again struggled against the feeling that our effort here was both useless and wrong. Truth speared my animal heart. There was no going back, not for me or any of these here among the trees.

The old man laughed suddenly. "I can see by your faces," he said, "that you don't know what to think, that you don't even know what it is that you do think!"

He was right. I was here to find out, and O'Connor was going to help me, and himself, by helping me retrace my own old steps. Maybe there was something I had overlooked, I told myself with a futile hope.

"You don't have to die," O'Connor said with a strange and sudden kindness in his voice. I had never heard it before.

The old man laughed. "We all die."

"Do you truly believe that?" I asked. "That dying can't be helped?"

He shrugged. "Something you can't fix will kill you all one day. Your cities will stand empty, and we will come to laugh in them."

It was a delusion, but I didn't have the heart to say so to his brave, beautiful, bearded pride.

"Why do you think you will live and we will die?" O'Connor asked as if he almost believed it possible.

The old man grimaced at him but responded to me. "We're not many, and we don't need as much as you do. That will save us."

"Poor fool," O'Connor muttered, and I wanted to explain to the old chief that death belonged to an earlier life of competition, to a way of blindly shuffling the genome that was no longer relevant. He smiled at me as if he were Ulysses refusing the gift of immortality from the gods, committing himself to a mortal life. "Get over it," I wanted to say to him, "give up these old views of death. Time to move on with the life of your kind. Try new views." But I held back. Words would be useless. He would have to see for himself.

"Do you really believe that we will perish?" asked O'Connor. "You must know it's not possible, or even likely."

The old man licked his lips. "There is a flaw that will kill you all."

"What is it?" I asked.

He shrugged again. "We don't know—but we believe it to be waiting."

"Where is it?" O'Connor demanded.

"Deep inside you," the old man said with a terrifying conviction. "You are all weak and afraid that if you leave us alone we will grow strong and come out to kill you. That's why you want our death. But when you kill us, all that is strong will go out of the world."

Ignorance can imagine anything, I said to myself as I gazed into his eyes, where it seemed to me that every second glance looked inward and saw death approaching; yet he seemed without fear, secure in his story.

There were those who feared these scattered tribes for the possible diseases they might harbor and one day release; and those who simply couldn't stomach the life of any unchanged humankind. Its simple existence was an insult. Here was humanity at its default setting of behavior, able to survive anything except our indifference, which was as good as malice. I thought, maybe the best thing we can do is disappear from their minds, like an old devil. They would then die away in peace, or come up in some different way.

I was lying to myself, of course. Humanity had to do things in steps. First had come the genetic therapies that no one wished to refuse. Then came a double life-span. And now that indefinite life-span was the norm, population was in serious decline, for reasons that horrified

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some of us and encouraged others. Indefinite life was now a right, to be extended to all who wished it. And I was hunting down the last unchanged groups of human beings and offering them life, cutting them off, in some views, from the afterlife and the fellowship of God, enforcing human rights, including the right to our way of life. Offering was a kind way to put it. Yet if the squads failed to enforce life and preserve it, then we would once again make compact with death and all its past waste of humanity. Behind us stood uncounted millions of dead.

The old man said, "If one culture dominates our planet, there will be no place left from which a different culture may arise. There will be no new ground, as Toynbee once said, from which it might spring."

"That was true," I answered, "when we did not have a permanent, ongoing culture."

"We are looking outward . . . " O'Connor started to say.

"Really?" the old man said with a smile. "You believe this?"

"Yes," I said. "New ground waits beyond this world."

He smiled again. "Are you certain that you will be able to benefit from it?"

O'Connor looked at me and said, "He's read a few books."

I gazed into the face of our fathers, and could only think that we had come up faster and held them back and were now trying to drag them after us into the new heaven. Nothing more. It was, of course, a bitter half-truth's plea I was making to myself. I would have to be insane to believe what these people believed. Where the many will go, a few must go first. We were way past that. Today, no human being should die needlessly. With longlife, even the most ignorant of these sitting in the growths before us would have time to be raised again—taken by force if necessary and educated, made to see. When you lengthen someone's life, you help them see enough to change their minds. You give them time to think differently.

What we were here to do was good.

I peered into the darkness, hoping to glimpse a child in the foliage, thinking that if I saw a young face or two I might not doubt the rightness of my actions. A child that would never know anything better than what shone now in its eyes would tell me I was right.

But I saw no children in the dark. The tribe was not reproducing. If anyone could be saved, it would be these living—surviving to become their own posterity, after their eyes and minds were opened.

The old man suddenly made a terrible sound in his throat. He stood up and spat on the ground in front of us. There was blood in his sputum. It glistened in the dancing firelight.

"You have made it hard," he said, "for all that is unlike yourselves, including the beasts. You have wounded the wind itself, as if you were angry gods . . ." He pointed at the bloody slime at his feet, then staggered back. "No one should be able to wound the wind," he added as he found his footing.

I looked at him and wondered whether I could see him as anything but beastly, despite the ingenuity and courage that drove his life. It would be useless to tell him that the planet was recovering, that no new harm was being done.

He grinned at me through rotting teeth, and I knew pity. There was no life here, I insisted to myself, only a prison of nature that had reared itself to be a test of survival and selection, and was no longer sifting the generations. We had stopped its death-dealing scrutiny. It was all up to us now, how we treated each other, even the worst of us. These people no longer needed to test themselves, or to worship the environment that had long ago spun their genome according to a different wisdom, and now had small pieces of fabric left over.

"Are you all right?" O'Connor asked,

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leaning toward me.

I nodded as I stared at the old man, who stood over us like a bear about to strike. I showed no fear, and knew that O'Connor was determined to do no less.

"I was one of these, fifty years ago," I said, "from this very area. These are their grandchildren, I suppose."

"Your relatives?" O'Connor asked.

"No way to tell." I turned and looked at him, feeling false, and said, "Aren't they all ours?"

The old man shouted, "You talk to each other as if I am not here!" He hated our words of concern.

I knew that by now this patch of forest was encircled by a barrier that could not be crossed. The catchers were waiting for first light, and would herd the tribe into transports as soon as O'Connor and I came out.

Decades from now these rescued would see the world anew; but in the protests that would erupt at sunrise, in the curses of the swiftly imprisoned, there would be no song of heaven.

The old man cursed at me, then went to his people. The four young men who had sat with him gave us fearful glances, then retreated. I heard him talking furiously as his people gathered around him, and I felt the futile loneliness of his leadership.

I stayed and listened to the explosion of cries that morning, to face my own feelings. I needed to stay and listen and force my feelings to march from darkness to light. And as I listened, I struggled to confront those protests with the reality of what would happen to these people, as they were awakened to a new life.

They would be taken to a center, washed, dressed, and fed, brought up to nutritional norms that would alter their mental performance, then educated for several years until their intelligence caught on by itself to who and what they were and what they could become. And from then on they would become partners in their own transformation into longlifers, free of death's waiting blackness. Oblivion had waited a long time to open at their feet, but would now be cheated. They would live to awaken from a nightmare.

The past would die within them, and new pasts would begin to grow in their minds, I told myself as I defended plucking them out of this place where once I had lived. That life had been scarcely better than that of the marsupials of a hundred million years ago, eating the eggs of the dinosaurs, waiting for something to wipe out their large, tyrannical neighbors. And of course, those little mammals from which we grew could not have known, and it might have been otherwise.

And I wondered how we lived without ghosts, in spaces without too much past, free of bitter rights and wrongs. How had we learned to do this? How was it that the tides of failed times no longer washed through our souls? They still flowed and ebbed within me, carrying poison to my mind.

When the last cry of the captives was silenced, I came out of the patch of forest and looked around at the dusty plain, then up at the cloudless sky. The catchers were gone into the blue with their human cargo. Somewhere far above, the past's devils were still crying out to heaven. I heard them even though I could not hear them.

I looked back into the forest. A bush stirred.

And I realized that the old man had somehow escaped the roundup.

He came out to me with a knife in his hand, and for a moment we stood facing each other. He was sweating and breathless. His right hand gripped the knife below his breastbone.

"I do not want to have my eyes opened," he said. "I want to die as myself."

"But you don't have to die," I said. "You'll be a young man again."

He took a deep breath, and I saw that he was trembling. "So you say. But who I

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am now . . . will die."

"But you'll remember."

I could scarcely remember, and I didn't want to think why I continued to come back to these places. Was it to test myself against the animals, to prove to some secret self that lived within me that I was still as strong and brave as they were? What longing had brought me before this man with a knife?

"Leave me be, son," he said. "It's up to you now. I don't have long."

"But that's mindless," I said. His willingness to die was fearful, yet I respected it. It was insane but admirable. It was that willingness, I knew, that had brought him survival, even victory. To risk death was a test of his world's willingness to let him live. But sanity required at least some agreement between one's inner life and outer reality. This man's environment was gone. His loyalty to it was an empty gesture.

"Leave me be," he said. "Count me dead."

I hesitated before him, as if he were a great judge. He had lost his tribe to a world he could not respect, but which still feared him. Knowing that fear fueled his resolve.

"What can it be to you?" he asked.

"I'll know." For a while, I thought, feeling ashamed.

"I'm no good without my people," he said. "I have led too long."

"You'll meet them again," I said, "and know them in different ways, in better times and places."

"Truly?" he asked.

"Yes," I said, feeling a liar. "You'll learn anew, live anew." I felt a rush of fear, but here was my chance to count, at least once, in a personal way, to open a nearly closed mind and see it flourish. If I failed, then I would have to live with a shameful memory, and one day delete it.

"Will I have to go . . . in one of those skycars?" he asked, still holding the knife at his waist. Was he going to kill me, or himself?

O'Connor came out of the forest and stopped a dozen paces from us.

I looked away.

The old man saw his chance.

He raised his knife.

And as I waited to feel it pierce me, I wanted it to pierce me, to feel the pain of its point more than to die.

O'Connor stunned the old man and the knife fell disappointingly at my feet. The old man collapsed to the ground.

O'Connor looked at me, and I knew that he had heard our conversation.

The old man was strong. He stirred, then opened his eyes as if surprised to be alive.

"So what do you think?" I asked O'Connor.

He adjusted his hat and smiled.

The old man was on his knees now. We helped him to his feet.

"I don't want to fly," the old man protested.

O'Connor said to him, "Don't worry. You'll come with us. We'll go back the way we came, low over the ground."

The old man looked at us like a defeated but proud child.

Some fifty years later, in the spring of 2154, I chanced upon the old man in Australia, during intermission for Mozart's *Don Juan* at the Sydney opera, and I did not know him. He was much younger, but still sported a beard. There was no gray in it.

"Say, didn't I once try to kill you?" he asked. A well-dressed young man who might have been his son stood next to him.

I gazed at them as if through a fog, but finally our first meeting came back to me, more feeling than image, carrying a sense of menace as I recalled my years of missionary work.

I nodded vaguely, and feared for an instant that he might want to finish the job.

He glanced at the young man next to him, then smiled at me through perfect teeth and said, "Whatever was I thinking?" as he shook my hand. ■

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The Perfect Story

Robert Scherrer

Benny slammed open the door to my office and dumped a pile of papers onto my desk. "We've had more than 300 complaints in the last hour," he said.

"All the same?"

"Identically the same. See for yourself."

I grabbed the top sheet of paper and began reading. Then I wadded it up and threw it against the wall. "Damn."

Our company was built on three great ideas. The first two made us rich. The third one ruined us.

Benny Sato supplied the first idea. I first met Benny shortly after I had taken over a floundering Silicon Valley software firm and was in the process of running it completely into the ground. Our flagship product was a program called WritersAide 1.0, a pathetic word-processor with lots of bells and whistles. But there weren't enough bells and whistles to compete with the big boys, and my technical know-how was pretty limited. I still thought Java was an island in Indonesia. So when Benny came bouncing through my door with his Stanford Ph.D., I saw my salvation in the flesh.

"Benny Sato," he said, extending his hand. "I've been doing some consulting work for your company. Your product stinks, but I can fix it." Benny was never one for subtlety.

"I'm listening."

"Well, the problem with your program, actually the problem with all word-processors, is the 'dumb' nature of the spell-checkers and grammar-checkers. There's not one out there that can tell you when to use 'it's' and when to use 'its'. But I've written a neural-net program that can do it."

As far as I could tell, Benny's "neural net" was some sort of program which could be trained to recognize patterns. Benny fed it a whole bunch of English sentences, and then it learned to recognize misplaced words and poor grammatical constructions, almost like a human child.

When we incorporated Benny's neural net routines into WritersAide 2.0, our

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sales skyrocketed. We sat on our success for a few months, and then I had our second great idea. "Benny, couldn't we use your neural net to improve the content of the things that people write? Suppose we fed it all of the great works of literature. Wouldn't it learn how to imitate them? Then you could insert your own piece of writing, and WritersAide would polish it up."

Benny disappeared for a month and came back with WritersAide 3.0. We fed it Hemingway and Dostoevsky, and it produced short declarative sentences about deep philosophical questions. We added Twain and Faulkner, and the program veered toward wry comments on the lives of inbred Southern eccentrics. But after training the program on more than a hundred famous authors, we reached a nice median. A user could input any piece of prose, and out would come a beautiful, polished final product. We were ready to go public.

WritersAide 3.0 was an instant hit, and the orders started rolling in faster than we could fill them. But within a year the store shelves were clogged with clones, and our market share began to plummet. That's when I came up with our third idea. "Benny, we need something unique to stay ahead of the competition."

"Like what?"

"We only had time to train the neural net on a limited number of authors. But there are thousands of pieces of literature posted on the Net. Suppose we redesigned the program to scan for these literary masterpieces when no one was using it, sort of like reading in its spare time." Benny thought this was a great idea, and soon WritersAide 3.1 was released to the public.

Our new program was a bigger hit than the original. But then we started receiving disturbing complaints. One customer had written a romance novel about an English nobleman in love with two different women, and WritersAide turned it into a tale of a businessman tormented by the need to choose between his Mac and his PC. A college student complained that his research paper on the Normandy invasion had been turned into an article about the invasion of Earth from the planet Zorcon in A.D. 2230.

Benny went into a panic for two weeks and returned with a troublesome answer. "Our neural net is absorbing everything on the Net. We didn't put any filter on it. Almost 90% of everything on the Net is computer-related, and most of the literature is science fiction. Hawthorne and Tolstoy and Melville are being crushed under the weight of galactic empires and video accelerators."

"Can we stop it?"

"Not likely. Each individual copy of the program is getting a unique set of inputs, but they all seem to be converging on the same final state."

Within a few more weeks, every copy of our program had reached the same configuration. Benny called it a "degenerate final state." I called it bankruptcy. No matter what written material was fed into the program, it spit out the same piece of drivel. The neural net had read everything on the Net and combined it all into a single "perfect" story.

I picked up the wadded-up piece of paper from the floor and slowly unfolded it:

"Dear Sir or Madam, I am sending you this message to complain about your program, WritersAide 3.1. No matter what I insert to be edited, the program produces the same final output. I have enclosed a copy of the program's output. As you can see, it bears no resemblance to the original." I turned over the page to read the other side, but I already knew what I would see:

"Benny slammed open the door to my office and dumped a pile of papers onto my desk. 'We've had more than 300 complaints in the last hour,' he said . . ." ■

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THE ALTERNATE VIEW John G. Cramer

DECODING THE RIBOSOME

Twelve years ago, I wrote an Alternate View column (*Analog*, October 1989) reporting on *Nanocon I*, a conference that had just been held in Seattle on February 17-19, 1989. Nanocon I, which I helped to organize, was the world's first technical and scientific conference devoted specifically to the then emerging field of *nanotechnology*. Nanotechnology gets its name from the *nanometer*, a distance of 10^{-9} meters or roughly the diameter of a molecule, and the term refers to the technology for structuring matter with precise control at the nanometer scale, atom-by-atom or molecule-by-molecule, to form a prespecified pattern. In other words, nanotechnology is the general ability to build large or small structures to complex atomic specifications. In 1989 nanotechnology was a relatively unfamiliar concept in science fiction. In the past decade it has exploded to become a major theme of much science fiction, including my own novel *Einstein's Bridge*.

However, while there have been some impressive technical achievements in this area in the past decade, one of the major goals discussed extensively at Nanocon I has not yet been realized. That goal is the production of an *assembler*, a device that under programmatic control can assemble atoms and molecules to produce nanomachines, including more assemblers. Can we be sure that goal is actually possible? Yes, we can. We have what mathematicians call an existence theorem: biological systems as complicated as humans and whales and as simple as bacteria are already practicing nanotechnology by programmatically constructing proteins using the *ribosome*, nature's own assembler.

In this column, I want to describe the accomplishment in the past year of a major step on the path to producing a general assembler—the mapping of the complete atomic structure of the ribosome. I'll start by describing in some detail how the ribosome assembles a protein. (Warning to the casual reader: the inner mechanisms of life are rather complicated, so buckle your mental seatbelts!)

Proteins are strings of amino acids that self-fold into units that are the intricate and varied building blocks of all living things. Proteins form the structural members, regulators, defenders, catalysts, communicators, pumps, movers, and shakers of all living organisms. Each protein is assembled by a ribosome using a set of instructions encoded in a strand of messenger RNA (mRNA). The messenger RNA is a working copy of the information transcribed from the DNA "central library" in the nucleus of a cell, but in a slightly different form. DNA has a backbone of deoxyribose and phosphate supporting an alternating sequence of the nucleotides thymidylic acid (T), cytidylic acid (C), adenylic acid (A), and guanylic acid (G), while mRNA has a backbone of ribose and phosphate supporting an alternating sequence that has the nucleotide uridicylic acid (U)

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substituted for thymidylic acid (T), but otherwise uses the same C, A, and G nucleotides found in DNA. These structural differences make mRNA a more mobile linear sequence that does not have the DNA tendency to form a double helix. The linear nucleotide structure of mRNA is read like a strip of punched paper tape, three nucleotides at a time, by the ribosome as the protein is constructed.

The sequence of mRNA instructions for assembling a protein can be thought of as a long "sentence" constructed from a string of "words", each word consisting of three "letters" drawn from a four-letter "alphabet", with the sentence ultimately terminated by a "period" or stop command. The letters of the alphabet are the four nucleotides U, C, A, and G. In principle, there should be 4^3 or 64 different three-letter combinations forming words constructed from such a four-letter alphabet. Three of the three-letter combinations, UAA, UAG, and UGA, are used as stop commands that inform the ribosome that the protein sequence is completed and that assembly should halt. Many of the other combinations are redundant, with several different three-letter codes specifying the same amino acid. For example, the three-letter sequences UUA, UUG, CUU, CUC, CUA, and CUG are all instructions to attach the same amino acid, leucine. Because of these redundancies, the 61 possible three-letter combinations that are not stop commands actually code for only different 20 amino acids. Those 20 amino acids specified by the mRNA code are lysine, argenine, histidine, aspartic acid; glutamic acid, asparagines, glutamine, serine, threonine, tyrosine, glycine, alanine, valine, leucine, isoleucine, proline, phenylalanine, methionine, tryptophan, and cysteine. It is interesting to note that there are additional natural amino acids that are not on this list of 20, and those extra amino acids therefore cannot participate in protein synthesis by ribosomes. Are there protein properties that are not possible because of the restrictions of synthesis? No one knows.

The ribosome does not directly collect and assemble amino acids into proteins. It has help from special molecules of transfer RNA (tRNA)—short strands of RNA that act as the amino acid handlers in the protein synthesis process. The tRNA molecule contains a special anti-codon section containing the complementary three-unit sequence of nucleotides that matches and docks with the three-letter mRNA nucleotide code just described. One end of this tRNA molecule is attached to an activated form of the amino acid to which the three-letter code refers. These tRNA molecules collect amino acids, transport them to the ribosome, and participate in assembling them into a protein. At the end of this process, the used tRNA, now lacking its amino acid, is released. It then finds its way to a special protein enzyme that loads it with another activated amino acid so that the process can repeat.

The ribosome itself is a special molecule that comes in two pieces. The smaller piece is called the 30S subunit, and the larger piece the 50S subunit. Here, the S designations come from the sedimentation rate of the molecule in a centrifuge, which is related to the molecule's size and weight. In shape the 30S subunit is rather like the handset of an old-style 1970s telephone and the 50S subunit is like the telephone's base. The protein synthesis begins when the 30S attaches to the beginning of a strand of mRNA. Then an initial molecule of tRNA with coding that matches the first word of the mRNA strand attaches at the first, or "A" site, of the 30S subunit. Then the 30S and 50S subunits close together, like hanging up the telephone, trapping the mRNA strand in the ribosome's reading mechanism so that protein synthesis can begin.

The two subunits of the ribosome, now acting together, shift the mRNA

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and attached tRNA to the second, or "P" site, of the 30S subunit and allow a second tRNA molecule to dock with the three-letter mRNA pattern now at the A site. It is believed that a "proofreading" process somehow occurs at this stage, during which the match between the mRNA and their complements in the tRNA unit is verified. The amino acid at the end of the tRNA molecule at the P site is joined to the amino acid of the new tRNA molecule at the A site and deactivated, forming the first link of the protein's backbone. Then the ribosome shifts both tRNA molecules over one position, so that the first tRNA molecule moves to the "E", or exits site, of the 30S subunit. There the first mRNA molecule, now detached from its amino acid, is released to be recycled. A new tRNA molecule docks at the A site of the ribosome and protein synthesis continues.

The protein grows link by link as the mRNA strand is processed through the ribosome until a stop code is reached. When this happens, the ribosome opens, like lifting the telephone handset from the base, and the protein and last used tRNA molecule are released. Since the mRNA strands are often quite long, they may be sequentially threaded through many ribosomes in a row, with protein synthesis occurring in parallel in all of the ribosomes involved.

It is now clear that the ribosome is not a purely protein biological structure. About 2/3 of the ribosome's mass is composed of RNA with the other 1/3 made up of protein components. Further, it is now clear that most of the essential functions of the ribosome are carried out by the RNA components. Thus, the ribosome is what molecular biologists call a *ribozyme*, an RNA structure that acts as a chemical catalyst.

The two components of the ribosome are very different in shape and function. The 30S unit does the decoding and mRNA transport while the 50S unit is the catalyzer that, when properly triggered by the 30S subunit, actually produces the protein. The 30S unit has a differentiated structure with clear domain boundaries and flexible regions capable of the large movements needed to transport the mRNA strand through the ribosome. In contrast, the 50S subunit is relatively solid and monolithic, its components intricately folded and locked together into a rigid whole.

The decoding of the ribosome has proved difficult because the subunits are so large and complex. The standard method for such mapping is to collect a large quantity of the molecules of interest and somehow cause them to form a repetitive crystal structure that can be studied using the technique of x-ray diffraction. The 50S subunit has been crystallized and mapped by x-ray diffraction to a spatial resolution of 0.24 nanometers by group of molecular biologists from Yale and the Howard Hughes Medical Center. A group from Cambridge, UK, Salt Lake City, Utah, and Göttingen, Germany has crystallized and mapped the structure of the 30S subunit to a spatial resolution of 0.3 nanometers. The recent papers of the two groups published in the journals *Science* and *Nature* include elaborate stereoscopic views of the 50S and 30S structures and their substructures.

The group that mapped the 30S subunit also studied crystals formed when the 30S subunit was combined with certain antibiotic molecules that are known to interfere with protein synthesis in the ribosome. This provides additional information that promises to provide new insights into how antibiotics work and how they may be improved.

Therefore, we now have a complete atomic map of the ribosome. But having the map is not the same as understanding the territory. That work is now beginning.

The process of protein synthesis described above indicates that the ribosome, the cell's protein factory, is a

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complex and intricate molecular machine. It is a fundamental component of life-forms from bacteria to multicellular organisms, plants, and animals. It is a key element of life itself. We would like to understand precisely how this keystone of biological processes works. The first step in this process, the mapping of the structure of the ribosome, has been accomplished. The next step is to understand the map, and to reach an understanding of how the ribosome works. This will involve detailed computer modeling and testing.

We would also like to discover how the ribosome can be put to other uses besides the fabrication of proteins, how it can be modified, improved, and extended. Our goal is to take over nature's assembler for our own purposes, to put its great capabilities to our own uses. We are not there yet, but we are now much closer. ■

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THE HEIGHTS

Larry Niven

Illustration by Vincent DiFate

When cultures are different enough, their ways of coexisting can get quite peculiar!

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Clickety-ponk came wafting down the magnetic fields above Siberia in winter of 2041, the fourteenth chirpsithra liner to visit Earth in twenty-three years. My translator says that *Clickety-ponk* is a pun that means *Weary Light* or *Weary from Mating*. The vast soap bubble of a ship carried forty-one individuals of eight sapient species, five of them unknown to me. All strangers, of course. We'll not see the same liner twice in the same millenium.

One pair, called Warblers, looked like featherless birds. They spent a Tuesday making an aerie just under my ceiling. Tuesday night they sang for us, a concert attended by all the ship's wild variety of crew and passengers. We weren't expected to serve their drinks too, because the Warblers wanted us in the audience; but the seating! The Draco Tavern isn't designed as a concert hall.

But the birds were good! They held us rapt. They didn't need microphones, and translators gave us the sense of the lyrics.

Warblers might have been designed by Dick Rutan. A Warbler was the size of a winning jockey, with wings built something like a hawk's under a slick skin of what looked like natural cellophane. Above a foreshortened beak its head bulged: streamlining sacrificed for a larger brain, porcelain-white eyes that faced straight forward, and stiff canards steered by jaw muscles. They didn't use breathers. They wouldn't touch alcohol. They bought their food in the butcher shops in Mount Forel Town, and warmed it in a microwave oven. Their life-support sigils were almost the same as a human's, *tefee tee hatch nex ool*, and that was all I needed to keep them happy.

They spent a day on the Internet doing the kind of research a tourist needs. Gail helped with that.

Thursday they were gone.

Monday morning they were back, high overhead in their aerie, not talking to anyone.

* * *

Monday evening, a man and two children came in.

They had a Midwestern look, lanky and longheaded, with straight black hair. The boy looked eleven, the girl twelve or thirteen. The children gaped at the aliens. The chirps and some others waved; the children waved back. They were delighted, I judged, but the man was dogged and suspicious. He did not look like a dignitary or anthropologist or university man.

Nobody crosses Siberian tundra to the Draco Tavern in winter just for a drink, and we don't encourage children. I said, "Door, do these have business here?"

The voice of the door, and of the translators and all our other semi-independent systems, said, "This entity spoke of urgent legal business. He asserts that his boy was attacked."

I watched the man approach the bar, holding tight to the hands of the children, who would have hared off among the tables. "Who is he?"

"Z. Wayne Bennett, thirty-two, resides in Ketchum, Idaho, with wife Ida, thirty-five, two children—"

"Pause," I said, because translators at various tables were yammering. "Schumann here."

"Immature life-forms are dangerous, should not be admitted, not likely to be sapient!"

"Who speaks?"

"I am Ambassador-Regent Ven! We am not to be endangered!" The system drew blinking green halos around four lungfish in an overilluminated vat of water on tractor treads.

All of them? Make that thirty-eight individuals.

I said, "Translator, I'm on it. Tell them that they'll be protected."

"Tell all species?"

"Tell the most timid. Tell Ambassador-Regent Ven and whoever else is complaining. Can you handle it?"

"Yes." I heard hoots and whistles and

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a low rumble and a skittery rattlesnake sound, alien voices all jabbering at once: the Draco Tavern's translators momentarily linked to perform one service.

Bennett had nearly reached the bar when he suddenly pulled the children against him, pointed straight up and screamed, "That's them!"

The lungfish all burrowed straight down into mud. The rest of us all looked up.

The Tavern is built to chirpsithra design, though humans were the builders and the place is human-friendly. Chirpsithra stand eleven feet tall, and they like head room. Bennett was looking forty feet up to the aerie the Birds had built under the ceiling.

Two Warbler faces stared back for a moment, and then one bird launched and tilted into a tight spiral. It wore a thick silver plate with a small rocket pod sticking up on a fin, the base held in place by webbing across its puffer-pigeon chest.

Damage control needed. I eeled around from behind the bar, big smile, hand extended. "I'm Rick Schumann," I said. "You'd be Z. Wayne Bennett?"

He didn't look down, but his hand reached out. "Pleased to meet you, Doctor Schumann. This is Lilly, this is Hammett. Ham was the one attacked. What are you doing about these undead birds?"

"Hi, Ham. Hi, Lilly." I shook their hands. "Attacked?"

The boy grinned. In a sudden motion he peeled off his T-shirt. There were small red marks on both sides of both shoulders, nine marks and a Band-Aid.

Aw, shit.

The Warbler dropped lower. He was giving Bennett the creeps. For an instant I saw the Warbler as he did: a cross between a plucked chicken and a bluebellied demon, vicious beak, huge claws built for ripping, the head too human or not human enough. He landed halfway across the main room, on an empty table, and waited.

A child-stealing alien was about the worst publicity I could think of. "I don't see police," I said. "Or reporters."

"You will," Bennett said, "if we don't get this settled. Do I have to worry that my boy got infected with something weird?"

"No, trust me on that." No visitor carries parasites. It's damn few alien bacteria that have an interest . . . though I'm hosting one myself. That one got through by outwitting the medics.

"Here." I fixed a translator to his shirt collar. "Let *me* talk." He nodded once, jaw clenched. I led him and the children to the bird's table.

We had an audience. Even the lungfish had come out to watch.

The bird watched with unruffled dignity as I settled the Bennetts in chairs. I told it, "I'm Rick Schumann, speaking for—"

"I know you. That one shot my mate."

Bennett glared. I spoke before he could. "Your mate is accused of stealing a child."

"Stealing was not her intent, nor mine. We pick up chosen prey, fly in a circle of designated circumference, and set it down. No harm—"

"Her claws pierced his skin."

"We must acquire gloves. Hammett Bennett, we are sorry for your hurt. Doctor Schumann, this worked out well enough in France when I took prey."

Bennett didn't like *that*, though he held his tongue. I said, "What are your names?"

The bird shrieked musically, twice, then said, "I have been called Langue d'Argent." My translator said, "Silver Tongue."

The United Nations Free Sky (or "Free Spy") Treaty allows satellites to pass over any country at ninety kilometers or above, and any observer may watch it if he can. The Warblers took a lens lander, the smallest of *Clickety-ponk's* boats, a quarter of the way around the planet and down in Alsace. The boat's stealthing

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was minimal and the sky, as Silver Tongue described it, was full of hot air balloons that day, but the Warblers would be gone before anyone could react.

What kind of idiots had the Chirps wished upon us this time? "In front of a sky full of witnesses, did you attack a creature that wore clothing?"

"I lifted and carried away a local sapient, a human child whom I had observed with family. These are not mere customs, but lessons hard learned. A creature not sapient can die of the shock or kill itself trying to break free, and herders or conservationists blame us. With a sapient creature we can reason, we can deal.

"The boy Andre Palanque-Delabrouille will verify that we agreed. I told him I had given him a ride; he accepted that. His female guardian screamed that I was an evil genie. When I offered a silver bar, she called me a silver-tongued genie, but she took it."

I said, "Now, I'm still playing catch-up, so give me a sanity check here—"

"We're sane."

"I'll decide that. You saw a child with an adult woman? You swooped out of the sky and picked him up in your claws . . . hands. Carried him how far?"

"Skreek!" (The translator whispered, "Two hundred twenty-three meters.") "In a loop, then back. The game requires go against the wind. Land, then talk to woman Rosanne Palanque-Delabrouille."

"Have you given thought to everything that *might* have gone wrong?"

"Much thought."

"She was an older adult. In good health? *She* might have died of shock. The boy will be afraid of plucked chickens for the rest of his life. You offered her silver to say she is the boy's guardian? What if she lied?"

"Surname was the same."

"Did she show you identification?" He shrugged; feathers would have ruffled if he had evolved them. "Dammit. You'd have no contract. The news might be breaking on CNN right now. A child attacked by aliens . . . twice now. The Chirpsithra ships could be asked to leave Earth."

"We harm nobody, and the hunt is fair," Silver Tongue said.

Z. Wayne Bennett spoke for the first time. "Don't give me that! Do you think I can't see you're wearing a flying belt?"

Bennett might be more sophisticated than he looked. Then again, Silver Tongue's gear looked very much like a Buck Rogers flying belt. Thrashing for an answer to Bennett's accusation, I noticed how many optical organs were pointed our way, and had my first bright idea.

"Z. Wayne, we're being stared at. I don't like it. Do you? Silver Tongue, is there room in your aerie?"

"There is room—"

"*We* can't fly," Z. Wayne said belligerently.

But I had the kids' interest. I said, "There's an elevator."

We'd used it to lift amazing quantities of meat. It was just a flat plate, wide enough for all of us. Z. Wayne's kids pulled him onto it against some resistance. We went up like a dream, with nothing between us and the drop, and unearthly varieties of sapience spread out below us. I was ready to snatch at a child, but Z. Wayne never let go of them.

Silver Tongue's mate awaited our arrival, then backed away to give us room. We stepped out onto spongy wickerwork woven from Siberian vegetation.

Her right side was swollen way out of proportion, a foam plastic pillow outlining a wing bound tight along her torso. The skin of her face was ravaged and smeared with gel, with two pocks in her beak and a patch over one eye.

Her belly was the same sky blue as her mate's. Where his back was a muddle of earth colors, hers was an elaborate scarlet design outlined in silver. I think the silver was tattooed onto a pattern evolved as a secondary sexual characteristic. I've never been sure. I picture him riding the wind high up, camouflaged

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against predators higher yet while he looked down for the bright flash and pattern of a possible mate. Mated, he would hunt for them both.

Bennett said, forcing himself, "Ma'am, how are you?"

She said, "Healing, thank you, Mr. Bennett. My eye is already replaced. Wing bones are growing in a template. My name is *Ssbreekeetht*. How are you, Hammett?"

"Healing too." She had him awed. "Silverback," he said.

"Show her," his father ordered.

The boy took off his shirt. Silverback looked him over, but came no closer. She said, "Z. Wayne Bennett, you must be wonderfully accurate with a shotgun."

"I didn't have the right load. If you'd been closer, you'd be dead."

"You shot me when I was carrying Ham, yet the boy took no harm." She paused to let us all realize how seriously the man had risked his son's life, then said, "No harm except that my hands convulsed when the blast hit me. Of course we must pay extra for his hurt."

"I thought it was more dangerous to leave him in a predator's grip."

She didn't answer. Bennett turned red. He said, "You hunted him wearing a flying belt."

I said, "Z. Wayne, it strikes me that a lift belt is no different from a hunter's gun except that it's not a weapon. Do you hunt?"

He glared.

"If you were strong enough, you'd hunt without the gun. *Tefee tee hatch nex ool* means their world has lighter gravity, that's the *tefee*, with air enough like ours to breathe, that's the *tee*."

"Still cheatin'." To the female, "And who gave *you* the right to hunt *my* boy?"

The female said, "Need."

I said, "Oh, come on."

She said, "Doctor Schumann, the hunt triggers our appetite. We need eat only seldom, but we must gorge then. You can testify."

Bennett said, "What?"

"I ported their stocks of their food from the market," I told him. "I haven't seen them eat, but I know how much food goes up. At first none, then *lots*."

"If we can't work up hunger during a hunt," she said, "we become malnourished, or we must take noxious medicine."

"Don't we all," I muttered.

"The effect is temporary. We will be lucky to last twenty days. Then, if we cannot hunt, we must endure cold sleep. We had expected to study Earth and mankind for two years."

I had given his children the thrill of a lifetime, then let Bennett confront the entity he'd shot. She had shown him the risk he had taken with his son's life. If Bennett could stay reasonable, couldn't I? But these idiots were throwing it all away, and I was getting angry.

"You don't have a problem," I said. "If you need to hunt, arrange a hunt! I've hunted with the Folk myself! They sold the TV rights and videotaped it!"

"Hunt by arrangement?" She couldn't believe it.

"Live at eleven," Bennett said grimly.

Better take care of Bennett's grievance first. I said, "Mr. Bennett threatens exposure, as is his right. The price of raising a child until he's finished college is around a hundred thousand American dollars, I think."

"Skeep? Price is stunningly high!"

"You might have got a better price by getting his agreement *first!*"

Silver Tongue asked, "What would you do, warn the victim?"

"Sure."

"No," said Silverback.

"The thing is," Bennett said doggedly, "my wife talked me into coming here first. She's walking today because her spine got fixed by some alien technique I can't spell or pronounce. I'm asking because you might . . . *might* have a rational answer. What gave you the right to attack my son?"

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"We must buy that."

"After stealing it!"

Silverback said, "We hoped for two years on Earth, continue on the next liner. If Earth cannot feed us, we must endure cold sleep beginning tomorrow! Feeding aliens, isn't that your business, Rick?" She examined me hopefully; gave up and turned to Ham. "But you are harmed, debt must be paid. Skreee?"

Her mate said, "Price is ridiculous in the up direction."

Ham said, "I'm all right."

I *wanted* the price to sting a little. I said to the birds, "Your sense of proportion is way off. What if you did catch an orphan? There wouldn't *be* anyone to deal with."

"An orphan would be the business of local government," Silver Tongue said.

"Were you ready to ask the French government to *name their price?*" *Sacré Bleu*, I thought.

"Is France rapacious?"

"No, it's *governments* that are rapacious . . . and lawyers. You've attacked Ham in the United States of America, where lawyers are thicker than anywhere on Earth!" I had my second bright notion. "You try that again, you'll be lucky not to lose your place aboard *Clickety-ponk* to some small boy with stars in his eyes and a smartmouthed lawyer." *That* should push some buttons.

Ham stared at me. Then he pulled at his father's sleeve. "Dad?"

Silvertongue said, "You exaggerate for effect. I offer two bars silver, two pounds each."

Ham's eyes weren't really glowing, and no alien could read so subtle a signal. But Ham and his father were trying to interrupt each other, and suddenly Z. Wayne bellowed, "You would never see me or your mother again! Nor Lilly either! Lilly, talk to him! Silver Tongue, am I right? These ships go slower than light! Even if he caught a ride back from some other star, it could be a hundred years, or a thousand!"

The boy said, "But an *interstellar*—"

Silverback noticed what was going on. "Major decision, give up the past, adjust to faraway unknown future, as we have. Circle the galaxy or stop off at own risk. Up to a hundred thousand years before return. Wait until older, Hammett. Mister Bennett, we accept price to teach Ham through college as determined through the Internet, pay in United States dollars, twenty percent finder fee for rapacious bartender—"

"Hold up," said Z. Wayne.

"—Escrow account for you and Hammett until Hammett attains age of presumed wisdom, if you will sign now."

"There's nothing wrong with the price," Z. Wayne said. "No, dammit, Ham, we will not sue to get you a ticket on an interstellar liner! Silverback, I want some assurance that there will be no further hunting of children."

"We would have to leave Earth early," she said.

"You can't prey on children. No matter what you pay, who you pay. you still can't do that."

The birds were silent. Z. Wayne looked at me.

"I have a notion," I said.

Five months later I took my niece and her children to the Park.

They'd raised the price of tickets by sixty percent. The crowding was fierce. Marilyn was shocked.

"Relax," I told her. "This is Draco Tavern's treat, every dollar of it."

"But why do *they* pay that much? Most children aren't even wearing the hats! Those that are . . . four a day? Out of hundreds!"

"Under two hundred." We'd picked a Wednesday.

The young man wouldn't give Wayne and Becky hats unless Marilyn and I signed contracts as their guardians. Despite four children tugging at us, I took a couple of minutes to examine the contract. I wanted to be sure no sneaky little weasel clauses had crept in since we wrote it.

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A lot of parents were changing their minds after they read it. I signed.

"Ricky, *is* this safe?"

"Sure. Jael? Alvin? Han?" Had they changed their minds?

They made their intent clear, and Marilyn signed, and the kids put on the hats. Han asked, "Can I keep it?"

"It's a loaner," Marilyn said.

I said, "You can buy it when you leave."

Scattered through a crowd of a thousand were less than a hundred hats, all on children between five and ten, all flame orange with a wide brim for protection against the sun and against looking up. Children with and children without orange hats all looked up anyway as they entered the Park. We found cloudless blue sky, and the new tower.

"Where are they?" Denise demanded.

I shook my head. "The tower's theirs. They come when they want. Only the top, of course." Most of the tower was the Beanstalk Fall, with much too long a waiting line. "Hey, Dolphin Ride!"

"A prey who welcomes us is not acceptable!" Silverback kept repeating herself. She was *sure* I didn't understand.

"First remember what you're avoiding," I told her. "Two years in cold sleep, then off into the starscape. Even doing it my way, you'll lose time while the lawyers argue."

"No!"

"Bet on six months, plus or minus. You can't have everything. What you *can* have," I said, "is prey that don't know you're coming."

"Nonsense! They sign contracts!"

"Look again. The Park gets seven hundred people on a weekday, three times that on weekends. Half of those are kids," exaggerating a little. "You pick two in a day. Four if you can stand it. It's less than a hundred to one that any kid gets picked.

"A lot of them, kids and parents, will spend the whole time looking up." Memo: Be *damn* sure the Park makes dark glasses available! "You don't pick those. Ignore them. Others will forget you're there. You're not on a schedule. It's an *amusement park*. They'll be *distracted*."

Z. Wayne had been working with a Palm Pilot. "Can you really get away with this? You're selling very little. Pot odds are of any kid being carried one and a half feet by two point two pounds of bird."

"Most of them won't wear the hats! Z. Wayne, they'll pay extra to see *some other kid* carried off. Most of the kids *with* hats won't get more than that."

"They'll never buy it," said Bennett.

"Shall I put out offers?"

"Try it," said Bennett, and "One may ask," said Silverback, and "Scraww!" said Silver Tongue. So I put in calls to Disney, Knott's, Six Flags. . . .

Music from the sky.

We all looked up. The birds were there, black against the sun, singing their hearts out. They wheeled and sang for at least ten minutes above the endless line for the Beanstalk Fall, then glided behind the tower in a roar of applause.

I faced forward again. The kids were tired of waiting.

Screams. I looked around.

The birds had circled behind the tower, already diving, picking up serious speed. They fell straight toward us. Silverback pulled up and rolled, showing her silver-and-scarlet design, but Silver Tongue swerved and swooped and dropped on an eight-year-old girl.

For an instant I wished fiercely that Disney World had bid. All that empty land for the birds! And they could have been wearing yellow Mickey Mouse hands! But Disney hadn't even got in a bid; their lawyers were too timid. Silver Tongue's claw tips were sheathed in blue, the color of his belly, and the girl never saw them until they closed on her. We heard her scree-hee-hee-heeming, fear and laughter as she rose.

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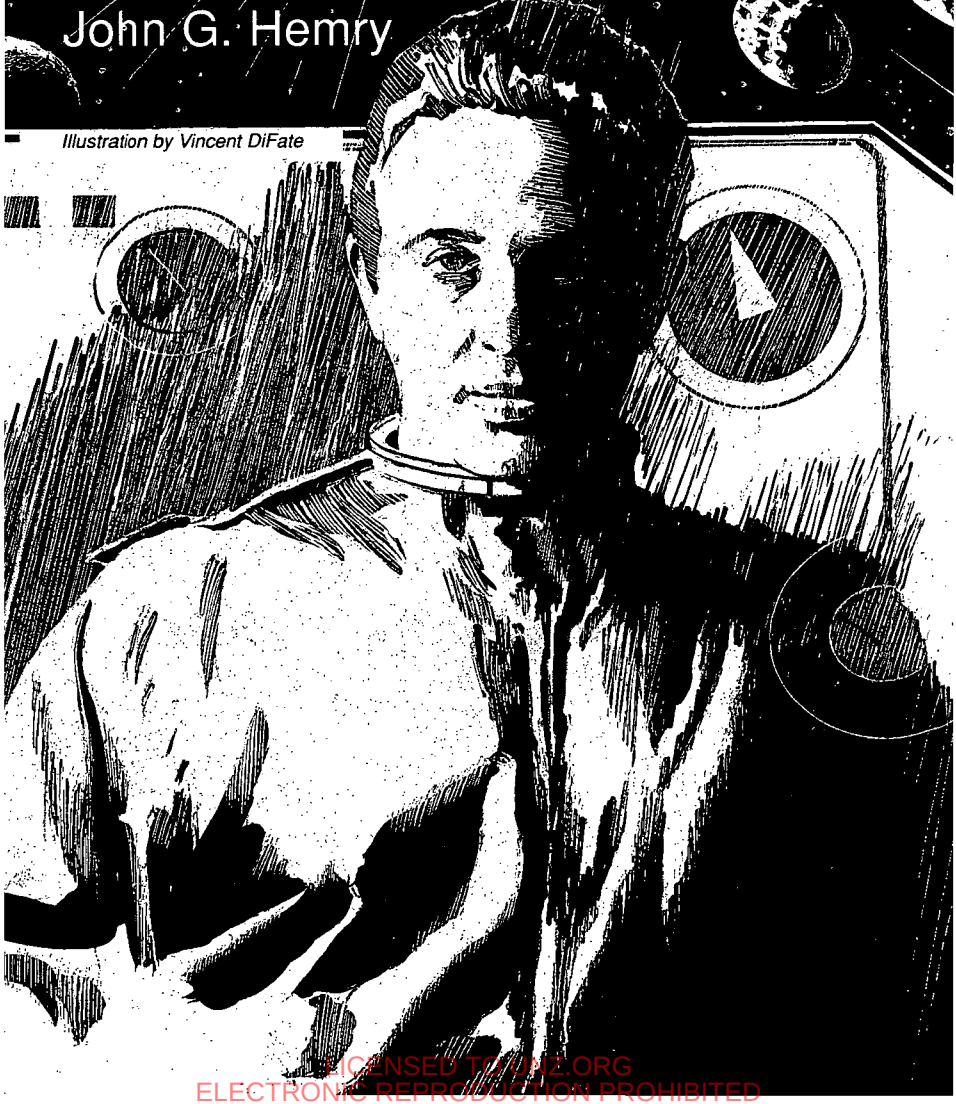
The best qualifications for a job aren't always what you'd think. . . .

Down the Rabbit Hole

John G. Hemry

Illustration by Vincent DiFate



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"We'd like you to pilot the next Prometheus probe, Commander Horton."

Commander Josh Horton fidgeted slightly despite the padding in his chair, his eyes darting around the conference room, resting for the briefest moment on the face of one NASA administrator before leaping to the next. Every face held the same forced cheerfulness, the same projection of an honor conferred, and the same more-or-less poorly hidden anxiety. "The next Prometheus probe?" he finally asked. "I didn't know there'd been a first."

"Well, you understand security, Commander, don't you? A successful test of a faster-than-light propulsion system would have incalculable significance for the human race. We certainly don't want to generate false hopes prior to a successful test."

"So the first probe wasn't successful?"

Administrator eyes shifted helplessly for a moment, then steadied. "No. At least, we don't think so. There's been no contact with any of the probes since they engaged their FTL devices—"

"*Any* of the *probes?*" Horton demanded. "There's been more than one failure?" Silence met his question. "Look, people, I deserve to know what's going on before you strap me into that can."

"Yes." The seniormost administrator nodded his head ruefully. "You do deserve that. There have been six Prometheus probes launched. None have returned. We have no idea why."

"Six?" Commander Horton's brain hazed momentarily, then he shook his head several times to clear it. "What, they blew up?"

"No!" The woman who'd answered looked around, embarrassed by her outburst, then repeated her reply firmly. "No. The only energy discharge noted was that predicted from the FTL transition. No other discharge. No debris. No events noted downrange."

"Downrange." Horton ran the word around his mouth for a moment. "Downrange can be measured in light-years, right? If something blew up when it came out of FTL you wouldn't see it for years, maybe."

"That's correct. However, sufficient time has elapsed so that we should have been able to observe such events from the tests by now."

"I see." Horton licked his lips, closed his eyes, then nodded. "Well, I guess we've got to keep trying." Then his eyes shot open and he looked around the table again. "Wait a minute. You said you wanted me to pilot the probe. But I'm a Systems Officer, not a pilot."

"Yes, Commander. We know that. That's why we're asking you to, uh, occupy the probe for this test."

Earth's sunlit arc, splashed blue/white/brown, hung within Josh Horton's line of sight. Next to the small viewport stood Dr. Orasa, waiting patiently for Horton's attention to return to her. "Sorry, Doc," Josh apologized. "I've never been up here on the station before. The views are pretty impressive."

"That they are," Dr. Orasa agreed. "Seeing the Earth from here always reminds me of that scene in the movie where the waltz is playing as the space station rotates majestically. Of course, our station doesn't rotate. Do you remember that scene?"

"Oh, sure. Everybody involved in the space program knows that one. But that's not the movie I was thinking of just now."

"Really? Some other space epic?"

"Uh uh." Josh smiled in half-embarrassment. "I was thinking about the old musicals. You know, with the spectacular dance routines."

"Yes . . ." Dr. Orasa replied with a mix of puzzlement and patience.

"I always loved those routines. Watching Gene Kelly and Fred Astaire and Ginger Rogers and Ann Miller dance like you figured angels would if angels ever acted in films with silly plots. So, I was

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looking out and thinking what kind of dance routines those people could have done up here in zero gravity. Imagine it!"

Dr. Orasa smiled in reaction to Horton's enthusiasm. "I suppose I can. Be that as it may, Commander Horton, I'm sorry my information won't be as dazzling. In truth, there's very little I can tell you."

"I thought you were a hot-shot quantum physicist, Doc."

"I am," she replied with another slight smile. "The problem is that just about everything we know about conditions on the other side of the light-speed barrier is theory. All I can do is summarize that theory for you."

Horton nodded somberly. "Because nobody who's actually been there has made it back."

Anguish shadowed her face. "I'm afraid that's correct. We don't know how moving faster than the speed of light will affect many things. Our nervous systems, for example. Or your perceptions of everything around you. Do you understand the concept of a frame of reference?"

"Yeah." Josh nodded again. "The Three Stooges did a routine about that once."

"The Three Stooges?" Dr. Orasa blinked in evident confusion. "They did a routine about alternate frames of reference?"

"Yeah," Josh repeated. "In the skit they were carpenters, I think, and Moe and Larry got into an argument over which way was Right and which was Left. So Moe calls over Curly and tells him and Larry to stand facing each other, then tells them both to point to their Right. Well, naturally Curly points one way and Larry points the exact opposite way, and Moe gets mad, calls them knuckleheads and slams their heads together. But they were both pointing the right way, based on their own frames of reference. Right?"

Dr. Orasa blinked again. "Uh, yes. That's . . . roughly the concept involved. You'll be perceiving the Universe in a manner different from any of us who aren't traveling at your velocity."

"But you don't know just what that'll mean."

"No." She managed another smile. "I hope you won't consider me a knucklehead because of that."

Josh smiled back, trying to ignore the tight knot which persisted in forming in his guts. "Nah. You don't know what you don't know, do you?"

"Uh . . . no. Good luck, Commander Horton."

"Thanks. One more question, though. Do you know why I specifically was picked for this mission?"

Dr. Orasa shook her head, frowning slightly. "No. I can't imagine it was because of your fondness for Ann Miller and the Three Stooges, but I don't know what criteria were used for your selection."

Half an hour and fifty meters later, Josh stood staring at the object which held his fate. Prometheus Seven, resembling nothing so much as an outsized round trash can with a slightly convex nose, sat locked within its cradle inside the space station's service hanger. Slight bulges around the probe's surface marked coverings for instruments and communication systems. Josh Horton ran one gloved hand along the titanium alloy skin of the probe, as if he could somehow feel the metal through the layers of his spacesuit, then levered himself into the cockpit where ranks of gauges and displays grown familiar in brief but intensive training now stared back at him. "Nobody ever told me why this thing is streamlined," he complained.

Colonel Linda Gutierrez smiled briefly. "No one knows what kind of resistance exists in the FTL environment. It's purely a safety precaution, just in case turbulence associated with the FTL transition, or resistance on the other side, might be able to harm anything sticking out."

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"Like my neck, you mean?" Josh muttered. "Is that also why there isn't any porthole?"

"That's right. That, and, um . . ."

"And?" Josh asked sharply.

Colonel Gutierrez grimaced but nodded in acquiescence. "Since you've met with Dr. Orasa you know we have no concept of how things will look in an FTL environment. The outside view may be profoundly disturbing. By using viewscreens you'll be able to shut off that view if you need to."

"If the viewscreens work. I mean, the lenses are electro-optics, and Dr. Orasa pointed out I'll be moving faster than their signals. Heaven only knows what I'll see. Or what I'll think of it." Josh rubbed the back of his neck, frowning in thought. "Now what does that remind me of? Seeing and moving fast and thinking. Oh, yeah. A long time ago I saw some show on the way humans see things. You ever hear about that?"

Gutierrez shrugged. "Maybe. There's a lot of interesting things about the way human systems work."

"You said it. Well, this one talked about how when you're spinning you see things rushing past in a blur. Only it turns out you don't."

"You don't?"

"No. They found out the optic system can't process something it sees that's going by that fast, so what your brain really sees when you sweep your eyes past something is a blank spot. But the brain can't handle blank spots, so it generates a picture of what it thinks should be seen, only the picture's blurry because the brain can't remember all the details. Cool, huh?"

"Unusual," Colonel Gutierrez agreed. "But, regardless, on this flight you shouldn't need to see where you're going, Commander Horton. After the FTL drive kicks in you do a straight run for ten minutes, then a timer drops you back into normal state. If calculations are accurate, that should place you about twenty light-minutes downrange when you depart the FTL state."

Horton's mouth worked as if he were tasting something unpleasant. "And if somewhere along that way there's some real big rock in my way? What do I do if I can't see it coming?"

Gutierrez shook her head, face solemn. "Commander, at the velocity you'll be traveling you wouldn't have the chance of a snowball in hell of turning quickly enough to avoid an obstacle."

"Great," Josh grumbled. "This is like putting on a blindfold and diving into a pool without knowing if there's any water below. I guess if I do hit something you'll see the fireworks."

"We haven't seen any fireworks in the prior tests," Gutierrez advised, then quickly added to her statement. "You shouldn't be able to run into anything. In theory, while in the FTL state you should not interact with mass traveling at non-FTL velocities."

"I don't know about you, Colonel, but I'd sure hate to be the one who found out that theory was wrong."

Gutierrez smiled. "Sorry, Commander. If it's any consolation, you seem capable of handling anything you run into. As long as it's not a real big rock."

"Thanks," Josh snorted, then glared directly at Colonel Gutierrez. "Look, Colonel, I'm about to risk my life, and despite everybody telling me about how capable I am, I've yet to get a straight answer on why I was picked for this job."

"You're a very level-headed, very capable individual," she recited, avoiding his gaze.

"Thanks, again. I must be the most capable guy on Earth. But that's not the reason. Why, Colonel? Why me instead of somebody like you? You're a pilot, with the training and reflexes to handle something moving fast. Me, I'm a ship-driver by training. I got picked for NASA because they needed people who could keep space station systems running, and shipboard training seemed to be a useful equivalent. So, why me?"

Colonel Gutierrez didn't answer for a

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moment, staring into the emptiness outside the hanger. "Because of what you said, Commander. You're not a pilot. Listen. The first six probes never came back. They've spent years analyzing the theory, the mechanical systems, the technology, the training. Nothing seems wrong. Nothing explains the failures. But we assume that on the other side of FTL things are going to be strange. We've just talked about that. So the human factor will be critical. After analyzing every aspect of the first six missions, we could find only one major factor the first six pilots had in common."

Horton took a deep breath. "And that was?"

"They were all pilots." Gutierrez shook her head angrily. "Maybe that's it. Maybe something in our training is leading us astray. Maybe. It's our best guess, our only guess, right now."

"Great." Josh stared at the bright displays on the probe's control panel, reaching out to slowly tap one of the two mechanical clocks ticking silently away, then glanced at the triple-redundant mechanical watch attached to his wrist. "Our best guess. Okay. At least that tells me something. They've built in mechanical backups to every electrical component they could, just in case FTL messes it all up. But humans only come in one standard configuration, don't they?"

"They come in many configurations, Commander. As many configurations as there are ways of seeing things. Pilots are one configuration. You may be a different enough configuration to make a difference."

"Colonel, I sure as hell hope you're right about that."

The shuttle, which Josh couldn't keep from thinking of as a tug, released the clamps holding the Prometheus probe in place. Pushed well away from the space station, facing into eternal emptiness, the probe ran its final automated checks before initiating the test flight.

Josh Horton watched lights flick on and off and digits cycle rapidly as the onboard computers checked and rechecked every component. He tried not to think about the flight, running through scenes from his favorite movies as the countdown dragged, but found his gaze repeatedly wandering back to the displays and to the mechanical linkage to the FTL drive which should drop the probe into normal state if the electrical timer failed to send the signal. Finally, every marker glowed green, every readout matched required parameters. Horton cleared his throat, acutely aware that his next words might be the last anyone else would ever hear from him. "This is Prometheus Seven. All checks complete. Preparing to initiate test flight."

"Roger, Prometheus Seven. You are cleared for test flight initiation. Begin countdown on my mark." Horton raised one hand over the mechanical backup timer, ready to mash it down at the same moment the electronic timer began counting down. "Mark." Horton's hand fell, and both mechanical timer and its electrical counterpart began scrolling off what could be the last ten seconds of his life.

Zero. Prometheus Seven flexed as if the entire probe were ballooning, its structure booming like a deep-throated bell. A moment later a secondary but still powerful crash marked the probe's guts collapsing back into place. Josh Horton felt his own body flex strangely in time to the probe's agony, jarring his senses unlike anything he'd ever experienced. *Some kind of shock wave when this thing transitioned to FTL, even though it's probably not a wave. Got to check the equipment. That had to mess up something.*

Everything he tried to look at was oddly hazed, almost wavering in blurry imprecision. Josh shook his head violently, blinking in rapid succession, but the instrument panel before him remained blurred. *Did that shock mess up*

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my sight or is this how things look when you're moving faster than light? How am I going to tell if that shock knocked anything off-line? It must have messed up the backup mechanical linkages. He squinted, trying to focus. The readouts remained fuzzy, but several resolved themselves into the same digits they'd held when he started. A close examination of the mechanical linkage showed it blurred in places but also apparently in the same configuration. The viewscreens showed as black blurs sprinkled with dancing spots of light.

Josh raised his arm to look at the watch on his wrist, staring in shock as the limb seemed to move in slow stop-motion jerks. A sudden sense of pressure on his wrist was followed by the realization that his watch was now pressed up against his helmet's face shield. *Faster-than-light speed. That must be it. My nervous system commands and feedback are moving slower than my environment. Just got to do things in stages. Allow time for feedback.*

Wrist and watch were still blurred, but by concentrating Josh made out the hour and minute hands on the watch face even though the second hand remained too vague to see. As best he could tell, no time had elapsed. *OK. That makes sense. It's surely been less than a minute since I punched into FTL.* He fought back a sudden wave of nausea, closing his eyes against the churning in his gut and a growing headache. *Dizzy. I'm dizzy. Must be because of the incredible speed I'm traveling. Or maybe that shock messed up my brain, like getting kicked in the head. That'd explain the way everything I see is blurred.*

He focused back on the watch, which still displayed no apparent change. *It has to have been a minute by now. It has to.* The image remained stubbornly unchanged; the minute hand wavering in his sight like everything else, but apparently unmoved. *How much has this disorientation messed up my sense of elapsed time? Maybe I can count down in my head—* Another surge of nausea hit, stronger, the world seeming to spin in time to the thunder of his pulse in his head. *Got to beat this. Whether it's FTL effect or not, I can't function when I'm this dizzy. Okay. Got to spot something.* He knew that, knew from watching Miller and Kelly spin around dozens of times without falling, that dancers in movies had kept their balance through those spins by focusing on a single point as long as possible, then whipping their heads around to focus back on the same point. A fixed visual reference. Like looking at the horizon to fight seasickness.

Josh locked his eyes on one segment of the instrument panel, a blurry section where four displays met in what should have been a point. But the point remained too vague to make out, and the nausea kept growing. Flashes of false light flickered inside Horton's eyes as the dizziness gnawed at his consciousness. *Can't keep this up.* The displays all showed the same data, his wrist watch the same time. *Hasn't it been a minute yet? It has to have been!* The image of the watch seemed to fuzz a little more, but remained stubbornly unchanged. He concentrated on the instrument readouts again, seeing vague numbers which all seemed to add up to normal states.

The instruments say everything's fine. Everything's not fine. Why am I so dizzy? Just seeing things blurry shouldn't make me dizzy. I know people who need glasses who don't get disoriented just because they're not wearing them. Sure I'm moving incredibly fast, but how can my brain know that when it doesn't have anything to look at that says I'm moving fast? Wait a minute. Josh fought down another wave of disorientation, trying to dredge up the memory which had teased him. *That story I told the Colonel about. The brain doesn't like what it sees. Makes*

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up a picture. Blurry? Could this be a case of that happening? But I'm seeing the instruments. They say everything's fine . . . there was something else. Something really important.

His heart pounding in time to his head, Josh barely kept from throwing up as he fought to recover the memory he sought. *I gotta remember. Something that might be the key to this . . . keys. That was . . . yeah. The brain makes up a picture when it can't handle what the optic system sends it. But that picture only shows what the brain expects to see. You don't see your car keys on the desk when you whip your eyes across because the brain doesn't know the keys are there and so doesn't put them in the picture it makes up. But what would that— Oh, my God.*

Horton blinked again, vainly trying to focus on his blurred instruments. *Am I really seeing these? I'm moving faster than light. My eyes and brain evolved to work with light-speed messages. My eyes are seeing something now, but what? Is it images my visual system can't handle, like that blank spot? If it is, then my brain's just making all this up. It's showing me what it expects to see, because it can't accept what it does see. It's showing me instruments which say everything is fine because that's what it remembers. It's showing me an intact mechanical linkage because that's what it remembers.*

He moved his arm again, sweating from fear and discomfort, trying to maintain concentration while his brain spun wildly. Stop-motion jerks brought his hand to the FTL control, then he slammed it down even as his consciousness ebbed.

Josh gradually became aware of his breathing, shuddering, eyes tightly closed as the world still spun inside. He forced his eyes open, blurred metal above them, causing his heart to pound again, but this time the metal resolved into firm detail when he concentrated. Lowering his gaze, he stared at the instrument panel. One screen displayed the outside, endless stars marching away. In a corner, the navigational system was running an analysis, trying to match the stars it could see with the picture expected an appreciable fraction of a light-year from home.

His wristwatch showed almost ten minutes gone by. According to the electronic readouts, slightly less than four minutes had elapsed. *So, best guess, I was in FTL state for six minutes. And the electronic timers didn't work in that state. Ugly. What about the mechanical backup?* Horton bent to view the linkage, shuddering as he spotted a component drifting loose. *Broke off during that transition shock, I'd guess. The mechanism didn't have enough flexibility at that point.* The navigation system chirped happily, displaying the probe's estimated position. Horton stared, dread fighting with elation as he saw the system readout declaring him to be approximately twenty-four light minutes from his start-point. *Wow. This baby's even hotter than they thought. I must have been going six times the speed of light. In terms of distance from home I just beat Magellan and Columbus all to hell. Now, how do I get* back *home?*

"You used chewing gum?" Colonel Gutierrez demanded, her voice over the communications circuit sounding disbelieving.

"I had some with me," Josh explained. The probe drifted, awaiting rendezvous with the shuttle sent to retrieve it. "My mouth gets dry sometimes when I'm tense, you know, so I usually carry gum. It worked to repair the broken link, and was flexible enough to handle the shock when I went back into FTL to get home."

"And that was why we lost the other six probes? Because of a single broken linkage?"

"No, Colonel." Josh tried to keep his voice unemotional, tried not to think of

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the six pilots before him who had ridden into oblivion. "We lost those probes because they were being controlled by pilots. Your guess was right."

"I don't understand," Colonel Gutierrez shot back in anger. "Why do you say that? What would pilots have done differently?"

"Colonel, they'd have done something fundamentally different. Because they were pilots. Because of their training," Horton explained carefully. "I'm not a pilot, but I know plenty of them. You're trained to trust your instruments, right?"

"Of course."

"Especially when you're disoriented, right? And lacking outside visual reference?"

"Naturally! It's when you're disoriented that you most need to refer to your instruments. You have to follow what they tell you or you'll crash. It's too easy to mistake what you think you see . . ." The Colonel's words trailed off. "I think I understand."

"Yeah. Pilots' training tells them that they must depend on what their instruments tell them when they get disoriented. It's drilled into them, isn't it? The better the pilot, the more experienced and the more highly trained, the more they know to depend on their instruments. Right?"

"Right." Colonel Gutierrez sounded as if she were in agony.

"But at FTL you're not seeing those instruments you're trying to depend on," Josh continued. "You're seeing an image generated by your brain. Blurred. Incomplete. And consisting only of whatever the brain remembers seeing from before or is otherwise convinced must be true. I thought I saw an intact linkage when there was actually a broken one there. I thought the instruments were saying everything was working fine. But you can't trust anything you see in FTL state. Or rather, anything you think you see."

"Like Alice," Colonel Gutierrez murmured. "down the rabbit hole into a world where nothing is what it looks to be. Wait a moment. Didn't you report you saw your arm move, even though the vision came in jerks?"

"I thought I did. Most likely, what I really saw was my brain knowing I'd moved my arm, getting feedback from the muscles, and calculating where I ought to see it based on how much it had moved. That's what made the picture stop-motion. I guess our brain's image-manufacturing center can't handle streaming video very well."

"That makes sense. But why were you different, Commander? What made you act against what your instruments were telling you?"

Josh shrugged, unseen by his listener. "Me? I got my training on ships. I don't trust instruments any further than I have to trust them. I assume stuff isn't going to work right. That training saved my butt. But pilots have to train and act differently."

"Pilots have to train and act in ways that keep them alive on Earth," Colonel Gutierrez stated bleakly, "but in ways that will apparently kill them in FTL state. What happened to them, Commander Horton? What do you think happened to the pilots we sent before you?"

"The transition shock surely knocked their mechanical linkages off-line just like happened to my probe. After that, I think they kept referring to their instruments as long as they could, probably seeing things on the displays that their brains said ought to be there if they were getting so dizzy, until they passed out. Any corrective actions wouldn't have worked because they were based on imaginary instrument displays. If the pilots started to recover, they'd just get disoriented again and pass out again. So their probes just kept going."

"Like being caught in a high-speed spin forever," Gutierrez noted bitterly. "Damn. Damn it all. Why did they have to die like that?"

Horton sighed heavily, shaking his head. "Because you can theorize about

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something and observe something from a distance and plan for something, but you never really know what it's like until you go there for real. That's why we need explorers, Colonel."

"And explorers don't always come back, do they?"

"No. They don't."

"We should have sent robotic probes! I told them! We could have designed enough fail-safes into each one so that eventually a probe would have reported back with the answer. We didn't have to risk humans on blind thrusts into the unknown!"

Horton paused for a moment, thinking. "I'm sorry, Colonel, but you're wrong. You know what saved me? Ginger Rogers."

"Ginger Rogers? The actress?"

"The dancer, Colonel. You know, I didn't get it right earlier when I said my professional training made the difference. That was only part of it. The other part was the old movies and the science programs I like to watch."

"I don't understand."

"They're what told me what was wrong. Movies and random bits of learning. What made the difference were things I picked up in the course of living, little bits of apparently unrelated information that came from being a human being with a life of varied experiences behind me. You see, Colonel? Those robotic systems you just talked about. How would we have known to incorporate the knowledge they'd need to realize what was wrong and why? Who the heck would have programmed a robotic explorer with what would have been regarded as useless trivia? But that kind of knowledge, the stuff a person just happens to pick up because people like to do that, that's what made the difference." Josh paused, remembering the overwhelming mix of exhilaration and loneliness he'd felt at being further from home than any human in history, imagining a machine in the same place, seeing the same things but feeling nothing. "Besides, we've got a universe to explore. Why would we want to let robots have all the fun?" ■

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The Gift of Unbinding

Paula S. Jordan

When a family disperses, little things take on disproportionate significance—no matter how big the family.

Illustration by Janet Aulisio

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The chanting was louder now. Joe Henson dropped the phone by the old vid screen and peered doubtfully through his office blinds. What if Nick Gianakis and his analysts at NASA were wrong? What if the President *could* be persuaded, as the voices outside demanded, to 'stop Spacehab now'? It wasn't likely. The Space Habitation project had been wildly popular when the previous Congress funded it. And yet, the group outside NASA's old VIP heliport in Washington, DC, was growing. The dozen or so that had appeared with the smudgy sunrise had drawn local onlookers in droves, then busloads of anticolonials from up and down the East Coast. By ten o'clock they were a milling, agitated crowd, trampling early tulips in the park across the street and waving green banners in the sallow light. When reporters arrived, paid agitators pushed through the crush at the curb to strut and stamp before them in the narrow street, yelling slogans, fists punching the sky, all tricking for the holocams and a few precious moments on the evening news. Joe couldn't believe it, all this trumped-up passion—against *Spacehab*—over a few storage canisters! But it was working. There was a new, angrier growl in the crowd's response. He smoothed his blue-gray uniform and snugged the spacer's cap over his salt-and-pepper hair. They'd be a mob soon. He'd better talk to them now.

He found the phone, set the buzzer on loud, and snapped it to his lapel. Then, pulling his still-solid frame to full height, he left the office and crossed the empty foyer to open the door. A shout went up and the crowd surged toward him, filling the street. Reporters yelled from the foot of the steps. A tweedy young man waved an "Earth First" placard. A woman with a green banner cursed him.

Joe shut the door behind him and went forward, smiling. Reporters leapt up the steps.

"Is NASA going ahead with colonization?"

"Will the new Congress rescind the Spacehab budget?"

"Any comment on the astronauts' storage canisters? Why were they brought here?"

"Who do they belong to?"

"What does the President say?"

Joe's smile faltered. "The President hasn't spoken," he said, trying not to sound bitter, "but I'll tell you what I can."

Not, he reminded himself, about the new colonies begun with Spacehab funding. The President would announce those in his long-overdue statement of support. Nor about the unknown snitch who leaked the news just hours ago, angering anticolonials and shaking the President's nerve. But the canisters—collected here in downtown Washington, to be lifted out as a human-interest news event once the President gave his approval—those Joe Henson could talk about.

He raised his hands. "I've only a few minutes. I'm expecting a call from the White House." The noise level dropped minutely. "The canisters belong to us, one for each off-planet astronaut, not to the government. They're personal, things we care about but couldn't take with us on early tours of duty." He gestured over his shoulder. "NASA has lent us this facility to collect and ship them now."

They all studied the familiar stone edifice. Built decades before as a secure transit facility for NASA dignitaries and their sensitive equipment, it had a camera-friendly, two-story façade, a high-walled rear compound, and a helicopter pad on the roof. First-mission cadets waved goodbye here. Heroes returned.

"Shuttles are more powerful now," Joe explained. "Off-planet assignments are longer. More astronauts' families are joining them—"

"Which has *nothing* to do with cuts in clean air and water funds!" the tweedy young man shouted sarcastically. The

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crowd hooted. He pressed his advantage. "What do you have in those canisters, anyway?"

"Keepsakes mostly," Joe said, "family pictures, old toys, a little jewelry." The man looked blank. Joe tried again. "Like the things you'd save first in a fire. They're priceless to you, but—"

"Priceless to us all!" someone shouted from the park. A disturbance rippled forward through the sea of banners and lifted fists. Heads and holocams turned. "These are *human* artifacts," the woman's voice went on, "made by everyday people, who carved out satisfying lives in the dust and sweetness of their *own* world." She came forward unhurriedly, shaking hands and slapping palms, sunlight glinting from her long blonde hair. Joe caught his breath. Denise! No. Claire? She stepped into the street, and was neither. How could she be? She glared at him, then turned to face the crowd, hands lifted as if in benediction. They went wild.

Joe knew her then: Chelsea Brennan, fiery spokeswoman—or rabble-rouser—for the Green Earth Party, with a cult following all her own. Bodyguards, too. A burly half dozen stood near her in the crowd.

She flung an arm toward Joe. "Shall we let this spacer send such *treasures* into darkness?" Her voice quavered, then soared. "Shall we let them take anything, ever again, where ordinary people of Earth can never go?"

"No!" the crowd yelled, "No!"

They were hers, every protester in the park. She spread her arms, reveling in the sound. Then a flat, amplified voice broke in.

"Colonel Henson!"

The shouting faltered. The front row jostled as more bodyguards elbowed a passage and a small gray man stepped through. Chelsea scowled, but waved the holocams his way.

"Marcus Whitley, *Washington Post*," the man intoned, smiling his famous, self-satisfied smile. "You must forgive us, Colonel. Like all Americans we are proud of our astronauts, and wouldn't refuse any trinket they want—on the ground." The smile vanished. "But to send up a whole shuttleload? Don't take us for fools, sir!" The crowd rumbled. Whitley's eyes flashed. "This *Spacehab* project is shooting hard-earned tax dollars right out into space, never to return!"

Joe smiled. "The tax dollars we spend in space will come back a hundredfold, Mr. Whitley, as new fuels and technologies, pure ores, plastics with unbelievable properties, without chewing up more of the Earth." He scanned the crowd. "The Europeans and Japanese aren't tying their spacers down. Are Americans losing their nerve?"

"No! We're losing *patience*," the tweedy young man shouted sourly. "You say you'll protect the Earth, as if oil and mining cartels will just roll over for off-planet sources they can't profit from!"

"They *can* profit from space," Joe said, "by ceding their holdings to the UN parks commission in exchange for shares—"

"That's tomorrow," Chelsea shouted, "or next century!" The holocams swung her way. "We want our tax dollars here, on the ground, to make our lives better *today!*"

The crowd roared. A muscled arm cocked in the front row and a drink carton zinged past Joe's ear. Time to give it up. He glanced at his watch—that was the signal—and took one more question. A reporter from a popular tabloid aimed his mike.

"A personal note, Colonel." It was a snide, insinuating voice. "You so favor colonization . . . yet here you are, still on the ground a *year* after your sudden return. Any comment, sir?"

Joe forced a smile, searching for a glib response. None came. "My . . . uh . . . own arrangements have nothing—"

His lapel phone buzzed. At last!

"Ah, my call," he said. "I have to take it inside. Thank you for coming." He

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waved to the holocams and retreated through the door.

"I'm in," he said as it shut behind him. "How does it look?"

"No more than a couple thousand," the voice responded. "But they're pretty worked up."

"Yeah. Well, let Gianakis know." He switched off.

The office was quiet after the hubbub outside. He closed the blinds, poured coffee, and settled back in his chair. The reporter's question nagged him, and Chelsea Brennan shimmered in his thoughts, blurring into images of his wife and daughter. The audio cube lay beside the player. He punched it in.

The music sighed and he was in space again, drifting on the tether, with Jupiter and the Sun at his back and the webwork of Ganymede Outpost glittering at his feet. He squinted outward, where the colony ship—his daughter's ship—flared with thrusterfire, then shrank to a dwindling blot against the stars.

The coffee cooled in the mug as the panpipes played.

It was pleasant on the Mall, walking coatless in the warm spring air. The Washington Monument pierced an almost-clear sky. The Capitol gleamed. Jetpackers in bright bodygloves whooshed above the long green lawns. Then the lean form of Nikos Gianakis, once Joe's commander at Ganymede Outpost and now NASA's Chief of Explorations, stepped away from a beer stand near the Smithsonian Castle and came forward with plastic mugs. Joe took one. They shook hands warmly.

"Thanks for getting me out of that mob, Nick. They finally left or I'd still be stuck in the building."

"Just another example of Washington magic," Gianakis said, keen eyes twinkling beneath a snowy thatch of brow. He gestured toward an empty bench and they settled comfortably. "You did well, you know."

Joe rotated the cold mug between his palms, recalling a tin-can world rowdy with first-mission astronauts, whom Gianakis had kept safe and in line. "You'd have done better," he said.

Nick studied him. "If you're thinking of Chelsea, you were wise not to take her on."

Joe shrugged. "I couldn't make sense of her."

Nick snorted. "Nothing to make sense *of*. Oh, there're plenty of brains in the Green Earth party—but Chelsea's pure emotion. As for Whitley. . . ." His ironic grin settled into a scowl. "Rumor has it Whitley will run for Congress. Ultraright."

"Ah. Politics as usual."

"Or as it was. The Greens haven't complained about space since the asteroid mine marches—2050's that was, you and Denise were on Mars—I thought they'd exhausted the issue. But Spacehab did divert some environmental funding, so they're marching again."

"And the far right is joining them?"

"The *ultra* right," Nick corrected. "The right always votes to limit tax money for space. But *this* faction. . . ." He grimaced. "Their wealth, their whole way of life, depend on everything staying just as it is. Problems and all. And colonization will not only change things; it'll shift control of space funding off-planet, out of their reach. We knew they bank-rolled the anti-Spacehab wins in the midterm elections, but we never saw *this* coming." He shook his head. "It's a weird coalition, but it's very, very powerful."

"Could they confiscate the canisters?" Joe asked.

"What?"

"As 'contentious property'—isn't that what they called it? Under the new Law and Order bill."

"Oh, the 'social disturbances' clause." Nick shook his head. "That'll never stand up in court."

"But if they tried it, seems to me the canisters could be tied up for a long time."

"It's possible," Nick said, "but I'm

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more worried about the public opinion polls. If the average voters turn against Spacehab—"

"Why would they? They'll benefit most."

"They don't believe it," Nick said. "They think the spacers will take the best of everything and fly away, leaving Earth in the same old mess." He scowled. "Whitley pushed those buttons perfectly."

"But no one's thinking about . . . what? Independence? For god's sake, Nick, there's too much work to do."

"You're right," Nick said. "For now. But it will come."

Joe almost choked on his beer. "Some joke," he rasped.

Nick didn't smile.

"Not a joke?" Joe caught his breath. "My god. So when?"

"Two years . . . ten." Nick shrugged. "Doesn't matter. Our job is to keep it peaceful. So we must be careful, early as it is, not to make anything worse." His eyes sought Joe's. "We may have to give up the canisters."

Joe stared back. Had Nick forgotten how it felt, blasting off into the sky; maybe for life, eager as the very rockets they rode—but leaving *everything* behind? He looked away. Had Nick, in fact, ever known that feeling? In some ways the man had never left the Earth, and probably never would.

"What about Matt?" Joe asked at last. It was a political question. Matt Cassell, Lunar Base commander and speaker for the off-planet astronauts, wanted to ship the cans now, to force the President's hand. This morning Nick had cautiously agreed.

"Things have changed," Nick said.

Joe drank. Nearby, a jetpacker strayed too near a sidewalk. A park cop with a remote override gun pulled him down, safe but sputtering. "You don't think the President will support us at all," Joe said quietly. He looked at Nick. "Even if you ask?"

"Not likely," Nick said. "We've had a noisy protest, and the push to rescind Spacehab is gaining strength. . . ." He stopped. "You didn't mention the Earth Center, or whatever you and Matt are calling it—that museum you're planning on Ceres. Can't say I see the point of it, but you could have used it to answer Whitley about the cans."

Joe shook his head. "It wasn't the time, and Whitley wasn't looking for answers."

"Right about that." Nick collected their mugs and stood up, regarding Joe thoughtfully. "I'll see what I can do."

Joe took the long way back to the heliport, mingling contentedly with tourists on the Mall. A year ago, when Claire shipped out, he'd come running home to Earth as if they'd reeled him in on a tether. He saw the wisdom in it now. He would learn to fit in. He'd be fine.

Balloons nodded above the crowd and a little girl in blonde braids raced along the sidewalk with a helium-filled Saturn on a string. He thought of Claire at five, on Bernal-O'Neill Station, as her grandmother led her away to Earth. Joe and Denise were leaving Ber'Neill, bound for Ganymede on the first trans-asteroid colony ship. They had applied early, hoping for berths on the second ship or the third, but with Joe's experience at Ganymede they had been chosen at once. Claire was a year too young to go. They held her and kissed her, promising that she would come soon, but she wept inconsolably. They took her favorite path through Ber'Neill's little forest, where the brook gurgled by a mossy bank. Claire was distracted by the sound, and Denise, inspired, cut a reed from the water's edge. Joe watched for the gardener as she carved a crude set of panpipes, lashing them together with strips of reed. She blew a few notes and Claire's teary eyes opened wide. The little girl reached for the pipes and studied them, turning them carefully in chubby hands.

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They parted by the brook. Claire kissed her parents, took her grandmother's hand, and returned her solemn attention to the pipes. Her first wistful, windy notes drifted back to them as her blonde hair disappeared among the trees.

Joe looked down at his wife, at the sunlight dancing on her own long blonde hair as she buried the scraps of the stolen reed—

"Hey, watch where you're going!"

Denise vanished in a swirl of dust and fine gravel, and Joe fell, rolling away with his arms before his face as a jetpacker thumped down beside him. He stood shakily, blinded by dust and tears. Someone reached out to him.

"You OK?"

"Yeah. . . ."

"Well, look at this," another voice jeered. "It's Henson, the space cadet, learning to walk all over again!"

"You sure you're OK?" the first voice asked.

Joe found his handkerchief and cleared his eyes. "I'll be just fine," he said, and took the fastest way back to the office.

The phone beeped as he opened the office door: Nick Gianakis again, with news that an astronaut had died, a miner along the Vesta Arc. The order to process her will was on the way. Joe routed the call to the vid phone, then stared at Nick's image blindly, trying to think who he knew on Vesta.

"Was it anyone from the Outpost?"

"I didn't recognize the name." Gianakis wore his 'focused' look. "I'd like to settle this quickly."

"Of course."

"And speaking to the President will have to wait."

"Sir—"

"I'm sorry, Joe, but it's is the right thing to do. The people have real concerns that ought to be heard. In a month or two—"

"But if they try to confiscate. . . ." Joe lowered his voice, speaking to the man he knew behind the all-business face on the screen. "One injunction and we lose control of the canisters."

"I tell you there are larger issues!" Gianakis leaned forward, his frown filling the screen. "You want Spacehab? Then we must be fair with groundside, and we must be *seen* to be fair. There's no other basis for negotiation."

"What about the colonists, Nick? The canisters belong to *them*."

Gianakis slumped. "What's your stake in this? You finally going back out there where you belong?"

"No. Still—"

Gianakis shook his head wearily. "Sometimes you disappoint me, Joe."

The screen blipped and died. Joe frowned at it, trying to reconcile this Gianakis with the commander he had known at Ganymede. Nick's fairness and leadership were legendary, but he had forgotten something vital. Out there, between the worlds, where specks of human light moved so cautiously outward, people survived as much on morale as funding. They would go on, Joe knew, without the extra cushion of Spacehab support, but the cans were their connection with the past, parts of themselves left behind. Withholding those—The printer chimed, and Gianakis' order spewed into the basket. *Controlling* those was just one more way dirtbound bureaucrats could jerk spacers around. Joe fumed at the thought. How long did they think they could. . . .

His eyes opened wide. Was *that* why Nick was worried about revolution? Well, maybe Joe should worry too. He sat down slowly, thinking it through, and keyed a note to Matt Cassell at Lunar Base. Then he swiveled toward the printer to read the form.

Maggie Phelps was from a later class than his. Their paths had rarely crossed. She had died alone, servicing a robot mining ship. A tool had drifted, a fuel line on her jetpack failed, and help had come far too late. Saddened, Joe looked

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up her canister number and took the creaking freight lift to the storeroom on the upper floor.

The meter-long gray cylinders stood on end, strapped on their pallets in back-to-back rows—titanium or plastic from Houston, newer composites from Hawaii—each stenciled with a name Joe knew. He walked the aisles feeling surrounded by friends, like shift change on the Outpost: a tired, smiling dozen half-swimming, half-flying toward the common room, while drowsy crewmates lagged the other way, toward duty stations and hours of vigilance. There were shouts and catcalls, backslaps that sent him flying, mock battles that dissolved in hysterics, tumbling in micro-g. He touched the canisters gently as he passed, as if he grasped the hand, touched the arm of a friend.

He found the one he sought and thumbed the security patch. Inside, packed in foam, were legal documents, a ukulele and books, toys, a child's dress, and one thing more: an antique kitchen tool, a carved wooden spatula with a chevron pattern cut into the blade. It was old and dry, with a lengthwise split beginning. A 'butter paddle' the bequest list called it, left to another astronaut, Dr. Ann Phelps, niece of the deceased. He stroked the smooth wood, wondering how a farmwoman would have used it long ago.

Leaving with the documents, Joe stopped at a table by the lift where Denise's canister rested beside his own. He should take them home, he thought, use some of his things—and hers—to warm his rented rooms. Silly to think they still belonged here.

He pressed. The panel clicked and slid aside.

Her first small telescope was there. He touched its battered shaft, seeing the child in California, lost in the million stars of the desert night. A stuffed gila monster grinned from a stack of broken-back books. There were pennants and pompoms, a pincushion encrusted with award pins. And wherever he looked, her sweet, brave face smiled back at him: in her spacer's cap or through the visor of her pressure suit, over Claire's crib or from their sleepsack at Ganymede. From her swath of bandaging in the radiation ward at Mars Base. From Claire's own face at the funeral, as father and daughter clung to each other, the red dust gritty between their palms.

Matt Cassell answered Joe's email by phone. A stark moonscape, a holo fed from the surface, textured the concrete wall behind his desk.

"Thanks for the note, Joe. We expected trouble, but this?" He frowned. "What we need now is a better orbit on Gianakis. What's his position? How will he advise the President?"

Joe studied the wall. "Nick will do what he thinks is fair," he said finally, "no matter who complains. Maybe he's right. There ought to be someone both sides can trust."

"Trust, yes. But depend on?" Matt shook his head sadly. "The spacers have decided, Joe. If there's a move to confiscate and Gianakis won't support us, we lift out the cans ourselves." He leaned forward. "There's a carrier out of DC—a former astronaut runs it—and a shuttle's on pad at the Cape. We could go tomorrow."

Joe hesitated, surprised that he was not surprised. Was there really so little to lose?

"People are pissed off, Matt. Anything could happen."

"It's a risk. We accept that."

"Maybe riskier than you think."

Matt rubbed his eyes. "Maybe it is. But these dirtside politicians are so tangled in intrigue you have to start a war to convince them you're serious." He raised his head. "Have you heard? They've started work on Ceres, clearing space for the Earth Center." What he meant was volunteers, clearing space in solid rock.

Joe smiled. "There's not a can in the

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lot worth more than a few bills."

Matt snorted. "So Gianakis would say." He shook his head. "A great spacer, Nick was. But he never cut loose from the ground. How do you explain the cans to someone like him? As an anchor? A direction home?"

"Something like that." Joe's mouth crooked in a slow, ironic smile. "And now you're going to haul them up."

"It seems that we are." Silence. Then Matt spoke again. "So, you gonna come out and run the Center?"

Joe let his gaze trail away, weighing a bland Earthbound future against the worlds he'd loved and left behind, because two who ought to be there had gone away.

"I'll have to think about it, Matt."

"Yeah. Well, think fast. We want you with us."

"Thanks. I'll let you know."

Joe slept little, and returned to the storeroom early the next day. The sealed canisters were launch-ready, but dozens of unclaimed bequest items had to be crated. He laid the last in sticky foam pellets and sat back on his heels, remembering.

Denise was six years dead when Claire reported for duty at Ganymede, fresh from the Academy and bubbling with excitement. There was a last-minute opening on the Uranus mission and few volunteers for it. Saturn and Uranus were nearing conjunction with Jupiter, like the alignment the Voyagers had used a century before. A settlement ship from Ganymede would swing past Jupiter, then Saturn, gaining speed from each g-field to shorten the flight time to the next, reaching Uranus in under four years. As the alignment passed it would take longer and longer flights to reach the colony, or to return. The tours of duty were effectively for life. But Claire was eager to go, and Joe, already missing her, had been harsh. She'd just looked at him, with Denise's deep-seeing eyes, and gone ahead with her plans.

When she won the berth, Joe took a month's leave. He had spent a week of it, moping around the Hyatt Jupiter trying to make sense of things, when he found himself in the arboretum, beside a stream like the one on Ber'Neill, looking at the reeds.

He cut the first ones wrong. But a few minutes at the computer and a second late-night tour of the gardens brought better results. So, much later—when he'd finally called Claire at Ganymede, and they'd filled her week of shore leave with a lifetime of father-daughter talk; when he'd returned with her to the Outpost to load her gear onto the ship that would take her away from him, to Uranus and its broken moons; when they had come at last to the airlock still trying to say goodbye—he had handsome grown-up panpipes to give her before he turned and flew away. Then he'd twisted the arms and called in the favors that won him the hour in his pressure suit on the end of the tether to watch the ship depart.

A month went by before she called, from far beyond Jupiter's orbit. "Rack a cube, Pa," she said. He did, and wept at the opening notes of her "Dance of the Jovian Moons."

The lobby door buzzed. Protesters, probably. Joe poured in more pellets and jiggled the crate to settle them. The buzz persisted. He cursed and ran for the lift, buttoning his jacket on the way. When he opened the front door, Nick Gianakis splashed in from a sudden rain.

"Morning, Henson. Sorry to bother you." He gave a brief conciliatory look. "Especially since our talk yesterday." He rolled his umbrella and looked briskly around the foyer. "Should do fine," he said. "It's you they want to see, in any case."

"Who?"

"Press briefing tomorrow on Major Phelps' bequest. May quiet things a bit, with her stuff going back to folks on the ground."

"But we can't. . . ."

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Gianakis laid a hand on Joe's shoulder. "What I need to hear is 'We can.'" He stepped into the lift. "Get the heirs here by one. We'll headline the six o'clock news."

"Nick. . . ." Joe slid through as the lift doors creaked shut. "There's only one heir, and she's an astronaut."

Gianakis turned. "Stationed where?"

"Ber'Neill. She's down on leave, due in DC tonight."

"Won't do at all. We'll have to—"

The doors opened. Gianakis stepped into the storeroom and stopped short, staring at the newly packed crates. He turned to Joe.

"Something you want to tell me?"

Joe snapped to attention like a freshout, then forced himself to relax. "I've been keeping some things for friends," he said quietly. "They want them back."

"And you're going to oblige."

"It seems fair."

Gianakis turned away, pacing slowly along the first row of cans.

"This is how wars begin," he said, tapping the floor with the umbrella. "One side claims something the other holds. The Trojan War, the Crusades—"

"Come on, Nick. These are keepsakes!"

Gianakis spun around. "Which you among others have made far too much of!" Then he sighed. "OK, there's less at stake here. Gives us a chance." He tapped to the end of the row and started back. "What if we hold the cans in trust, on Earth, as a link instead of a wedge between our people." He glanced up. "The ties are wearing thin."

Joe thought about it. "Where will you keep them?"

"What?"

"You plan to leave them here?" Joe gestured at the room. "Or scrape up funds for a repository? They'll be the focus of anti-space protest for years to come."

"We could disperse them—"

"And have a hundred points of protest instead of one. Of course you could hand them over to Chelsea. . . ."

"And your 'Earth Center' is a better solution?"

Joe smiled. "It's a children's museum, Nick. I'm sure there'd be an uproar at first, but yes, I think it would work. With the cans out of reach, people would forget. As for NASA. . . ." He grinned. "Think of the PR, Nick . . . kids in space learning about their ancestors on Earth. I bet the Center would send you vids."

"Not bad. But as time goes on—"

"As time goes on these could be the only mementos of Earth the colonists have." Joe crossed the floor between them, choosing his words carefully. "When you said that spacers would go their own way, you meant politically. But surely you realize . . . we'll be a starfaring race one day, generations of us living and dying in worldships between the stars. I keep thinking of the children, of all they'll see . . . and all the things they'll miss. But with a few relics, from these canisters, brought along on each ship. . . ." He stopped, then shrugged, and thrust his hands in his pockets. "Even if they only go to Pluto, they'll need something tangible from home."

Gianakis nodded. "Good thinking, Henson. Better than I expected." He studied Joe thoughtfully. "You were right to worry. The act to confiscate the cans is coming through committee. I could seize them today, if necessary, for the safety of the American people. Now you remind me that you *are* the American people, and how careful we should be to keep it that way." He smiled. "Even when you've headed for the stars. But we still have this 'uproar' of yours."

"Would something more from the astronauts help?" Joe asked. "A larger percentage of mine revenues . . . ?"

"Has to be real. They won't accept a token." Gianakis said. "Let's talk tomorrow."

Joe nodded, and ushered him into the lift.

"Trouble, Matt." Joe grimaced at the

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screen. "Nick Gianakis. He waltzed right into the storeroom. Almost fell into a crate."

"How'd he react?"

"Not happy," Joe said, "but restrained. You know Nick." He paused. "He could have seized the cans outright, but he's considering our compromise. I think he'll be straight with us."

"I'm sure he'll try," Matt said, "but he can't just hand us the cans. NASA needs the President and the President plays to the polls." He paused. "*Armstrong* can launch tomorrow. I think we should go."

"You're sure it's worth it?"

"Aren't you?" Matt asked.

"In the long run, yes," Joe said, "but we're burning some bridges here. I'd like to have avoided that." He sighed, then faced the screen. "OK. Tomorrow it is. What time?"

"Six a.m. Watch for helicopters."

Ann Phelps called at five. Her leave had been canceled. She had a few hours to collect her aunt's bequest and return to the Cape. Joe faxed her a map to his apartment and brought home the items she had selected from the bequest list.

Short of sleep and unused to full gravity, she sank into his sofa and accepted the drink he offered with a grateful smile. She sipped as she looked through the package, then set the glass aside and took the butter paddle in her hands. Joe sat across from her, watching her face as she stroked the battered wood.

"I've wondered about that piece," he said. "There's something so . . . personal about it, as if I could feel the carver's hands."

Ann nodded. "Maggie felt the same way. One of our great-grandmothers made it . . . no telling how many 'greats' back." She traced the worn heart shape at the paddle's end. "It was a wedding gift for her daughter, a gift of unbinding." She caught Joe's eye and laughed. "Maggie again, she loved words. But it was true. After the wedding, the girl and her husband climbed into a wagon and started west. Her mother never saw her again."

The breath knotted painfully in Joe's throat. But Ann went on, softly, her attention far away.

"She carved this little tool with her own hands, knowing how the girl would hold it, each day, to lift the butter from the churn and press out the whey. It allowed her to touch her daughter's life. And when the butter was finished, the girl would press the heart shape into the top of it and decorate the sides with the chevrons, and feel her mother's love."

"But you called it a gift of *un*binding," Joe whispered.

Ann smiled. "It made it possible for the girl to go."

"I don't—"

"It said that the mother understood, and gave her blessing. You see? It unbound their dependence on one another, but left their love whole."

Joe stood up shakily and lurched to the kitchen bar. He fumbled for the bottle and tried to pour, almost chipping his glass, then set them both down hard. Out there, he thought, near Saturn now and hurtling ever farther away. . . .

"Colonel? Are you all right?"

He struggled for breath. "Yeah. . . ."

She hurried over and helped him to the sofa.

"I'm sorry," he said. "I just. . . ."

"It's all right." She settled him and loosened his tie. "Deep breath now. . . ." He breathed, and she sat beside him, watching. Then she touched his hand. "Who was it, Joe, the one you tried to hold? Or did you let them go?"

He cleared his throat. "Some of both, I think. But in the end . . . I may have done all right."

She went to the bar and poured while he talked about Denise, and Claire, and the pipes. When she asked to hear Claire's music, he played her newest, the "Odes on the Rings."

"I couldn't bear it," he whispered as the music played. "Always alone. Al-

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ways. . . ." He smiled wearily. "I thought, back home I would be OK. I could pretend they were still out there."

"But you had friends."

"It didn't seem enough."

"And this is?"

He looked up. Her hair was dark, and shorter than Claire's or Denise's, but she smiled like someone he'd always known. "I work for the colonies," he said, "but soon even ground support will move offplanet, out to the places I've run from. And no, it's not enough."

It was late. She resealed the package and he helped with her coat. Then, going out the door, she turned.

"Something else about a gift of unbinding: if you let it, it can free the giver too." She smiled. "Maybe I'll see you on Ber'Neill?" He stared wide-eyed at the closing door. It clicked shut, and he found himself grinning. She was right. He was going back after all.

Joe packed, called a taxi, and got to the heliport by two a.m., but the protesters were there before him. He directed the driver to the rear compound and they got through the gates undetected, but as they unloaded his duffel someone shouted from the street. Joe paid the driver and slammed the gates behind him as a gang of toughs ran up to pummel the retreating taxi.

Joe climbed the back stairs to the storeroom and went to work, securing his and Denise's canisters, opening the helipad doors, forklifting crates and palleted cans up the ramp. By six he was done, peering out the office window into growing light. There was the mob; reporters pounded the lobby door; but where in hell were the choppers!

The phone beeped at quarter past six.

"They're in the air," Matt said. "They were late getting clearance. Someone sitting on the paperwork."

"The mob's back, too," Joe told him. "Maybe a thousand." A brick crashed through the window and Chelsea glowered from the street. "A thousand and one," he said grimly. "But the pad's secure and the cans are ready to go. Got room for a passenger?"

"Say the word, Joe. There's a seat in the last chopper."

"I'll see you soon, then."

"You bet."

Joe switched off. Chelsea and her swaggering bodyguards prowled the edges of the crowd. "Liar," he heard her say, and "thief." The crowd grew angrier by the minute. Marcus Whitley, candidate for Congress, took one look from his limousine and drove on. Joe scanned for weapons: bricks and pop cartons, a few bottles . . . nothing to bring down a chopper. And no way—shit! There *was* a way to the roof. And Chelsea had spotted it. She was gesturing eagerly to the left of the façade. Her bodyguards shoved through the mob in that direction.

Joe searched the room. No weapons. He rifled cabinets and jerked open a closet door. A baseball bat! He grabbed it, thinking fast. The helipad was two floors up. The stairs were too far and the lift too slow to get him there in time. He headed for the lobby door.

Reporters crowded the steps, watching the mob. He slipped out behind them, locked the door, and swung under the rail into the bushes. Ahead, above a stand of young pines at the corner of the building, rose the uprights and rungs of a rusty ladder. Joe hunched behind the bushes and ran for it.

"There he is," Chelsea yelled. Her ruffians dashed for the ladder, knocking stragglers from their path. Joe dove through the trees just ahead of them and scrambled up the rungs. Hands clutched his ankles. He swung the bat till they let go. Then he climbed.

A new sound rose above the din as three cargo choppers swept over the park. One landed on the roof and the mob howled. The toughs on the ladder swarmed over Joe's feet, trying to get past him between swings of the bat. Others scaled the swaying pines. Then a

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jetpacker shot skyward from the back of the park and headed for the chopper.

The crowd cheered. The tree-climbers surged upward. Joe struggled to stay ahead of them, listening for the approaching packer and battling the toughs below him at every step. He pulled above the treetops at last and slumped toward the wall, gasping loudly, till the thugs on the ladder caught up. Then he loosed a backkick that flung the nearest ones down onto the heads and shoulders of the rest.

An instant later he stood on the top rung. Ten, maybe fifteen seconds, and the toughs would be back. He turned outward, bracing himself between the ladder and the balustrade at the roof's edge, and faced the packer. The man came on grinning, uncoiling a chain to foul the chopper's blades. He was a dozen feet out of reach.

Joe wondered wildly if he should leap for the chain, but angry shouts from below told him it wasn't over yet. A line of police blue was advancing through the park. One officer aimed a remote override gun and the packer faltered. But he must have had an override of his own. He dropped a few feet and leveled out—still flying, but too low to take out the chopper without getting killed himself. He came on anyway, roaring obscenities, wobbling erratically as he tried to swing the chain around his head, charging straight at Joe.

Joe ducked and thrust the bat upward with both hands. The chain struck, then wrapped around it, almost jerking him off his perch. But his braced legs held, and the jetpacker spun out of control. When the cop with the override fired again, the man slammed into the crowded ladder below. It was too much. There was a low grating sound and the ladder, its thug capacity finally exceeded, shuddered and pulled away from the wall.

Toughs fell screaming into the crowd, and Joe, windmilling frantically, flung an arm over the balustrade. For a moment, he could see everything. The first chopper pilot finished loading and backed the forklift away. Winds whipped Joe's hair as the dark shape swung over him and the second took its place. Below, police fought through the mob to gather under the pines, all yelling at once. Then, as his arm failed, he saw Gianakis wade through the melee toward Chelsea.

As he slipped, Joe kicked away from the wall and leapt for the pines. Twigs gouged his hands. Branches bent, then cracked, and he went down hard among the police. Some officers fell under the thrashing branches. Those still standing searched frantically for the one blue-gray uniform among the dust-grayed, floundering blues.

Joe got his feet beneath him, wincing at a twisted ankle, and staggered into the park to find Gianakis. Everyone was yelling. Police and protesters stumbled around him in a blur. Then, in an opening between police helmets, came a flash of blonde. He reached through and grabbed Chelsea's shoulder.

"He spilled it, didn't he?" he yelled.

"What?"

He had both her shoulders now. "Gianakis. He's the leak!"

But Chelsea only laughed.

He wanted to shake her, hard, but stopped, shocked at his own rage. Then there were hands on him, breaking his hold, and someone pulled her away through the blue wall that had sprung up from nowhere, blocking him in.

He stood quietly after that, tensed but not struggling, aware only that the second chopper had lifted away and the third had thumped onto the roof. Then the police let him go and rejoined their troop, clearing the park and herding the ringleaders—Chelsea among them—into vans. Someone handed him his cap. He brushed at it idly, watching the last chopper, as Gianakis came to him across the grass.

"You didn't tell them, did you," Joe said quietly.

Gianakis shook his head. "*I* have tried

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to be impartial in this, but you. . . ." He frowned as he brushed off Joe's uniform, muttering over snags. He tugged at Joe's tie. "Never mind. You'll learn. For now—here, shake my hand. Have to be civil for the cameras."

Gianakis turned him to face a battery of holocams. Joe smiled and waved to them, his heart deadweight in his boots, as the last chopper lifted from the roof. But it didn't follow the others. It settled to the grass nearby, and Nick led him that way.

"You're letting us go?" Joe shouted, astonished, as they hunched to walk beneath the circling blades.

"I'm letting *you* go," Nick shouted back. "You read the canister issue better than I ever did, and you were willing to deal." He grinned. "Even with Matt Cassell whispering in your ear." His eyes flashed beneath the wind-whipped silver of his hair. "Be their negotiator, son. If I'm to keep peace, I need someone up there I can talk to."

"But. . . ."

"There's no time." He pushed an envelope into Joe's hands. "You have a shuttle to catch."

Joe climbed into the chopper, buckled in, and reached to close the door. Gianakis grasped his arm.

"The news," he shouted, "watch the news!" Then he shut the door and ran back to the reporters.

Joe nodded to the pilot. Engines thrummed and the park fell away beneath them. The pilot tapped a switch and a holo formed on the windshield. It was the President. Joe fitted a headset to his ears.

". . . My legal advisors have confirmed their ownership. I have therefore directed that America's citizens in space shall have their own property. . . ."

Joe looked at the envelope. For Nick, no doubt, this was business as usual, an unplanned but steady step on the way to peace. But for Joe, who had learned about such gifts, it was infinitely more. He snapped off the holo and looked out, suddenly aware how fine a morning it was. The sky was clear, and the old Virginia hillsides glowed in the early light. Something ancient within him had begun a slow unraveling: ties that he knew would never break, but could stretch to the ends of space. ■

IN TIMES TO COME

Our June issue starts off with a uniquely striking cover by Kelly Freas, illustrating an equally unique novella by Adam-Troy Castro. It's aptly, if improbably, titled "Sunday Night Yams at Minnie and Earl's," and easily qualifies as one of the most unusual and probably controversial stories we've ever published. I suspect most readers will also find it one of the most satisfying and memorable. I can't tell you much more than that before you read it, but I can hint that it deals not so much with any specific, single science as with the very nature of knowledge, and how we get it and what we do with it. It also happens to be a lot of fun.

Elsewhere in the issue we'll have stories by Pauline Ashwell, Laurence M. Janifer, and Michael A. Burstein—and, of course, Part II of Ben Bova's serial *The Precipice*. The science fact article comes from Mark S. Derzon, a physicist at Sandia National Laboratory, and takes a close look at one promising approach to the perennially vexing problem of fusion power. For decades we've been hearing that thermonuclear fusion would be the preferred power source of the future, but it has so far proved frustratingly difficult to make it work well enough to become a viable competitor. Might the "z-pinch" be the way?

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Even at a very slow pace, commerce is filled with intrigue and traps. . . .

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Illustration by Vincent DiFate

Edward M. Lerner

HOSTILE TAKEOVER

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CHAPTER 1

The celebratory entree was never in doubt: home-grown lunar beef. The flesh of cattle raised in one-sixth of a gee was *oh* so tender. The local side dishes were certainly satisfactory, if unexciting. If only some Loonie would figure out how to grow a decent wine grape—the Bordeaux, imported from Earth, was exorbitant. And delicious. And well deserved.

Kevin Aldrich slouched in his chair, pleasantly full. He refilled both his glass and his wife's. Simone raised her glass in tribute. "To a project well done."

"To exhibitionists," he sort of agreed.

"And to extraterrestrial voyeurs," chimed in Jeeves. The comments of the artificially intelligent agent arrived via Kevin's neural implant, effectively direct to his mind's ear. Simone hated those interruptions, which made her husband smile or frown or grimace for no apparent reason.

"I'm taking the evening off," Kevin subvocalized.

"Sorry." It wasn't, of course, but it had been programmed to observe social conventions. "Something came up I thought you would want to know about promptly."

He visualized a question mark.

"There's been a major system outage. An AI running one of the interstellar transceivers, no less."

It was beyond odd for a modern AI to seize up. This was an era of molecular-scale electronics and ubiquitous wireless and fiberless networks. There was just too much redundancy in computing and communications for a total failure to happen. "You're sure about this?"

"Honey?" His wife, despite his rave reviews, had resisted getting her own neural implants. Her glass was still raised, mid-toast. "Is everything OK?"

Kevin glanced at a short download from Jeeves. By implant-driven stimulation of an optic nerve, he viewed a bolded, italicized, large-font news summary: i-commerce link severed in freak accident! "Depends on your point of view." He clinked glasses with Simone. "Things look just fine to me."

Interstellar commerce: business done between the intelligences of different solar systems. The impracticality of physical travel between stars has constrained and shaped the nature of such trade.

Early in the twenty-first century, in the years that followed first contacts with nearby species, i-commerce was done exclusively as simple bartering by radio of technology concepts. The speed-of-light limitation on communications meant that each exchange took years. These round-trip delays greatly retarded the development of a common vocabulary and, hence, cultivation of more sophisticated trade mechanisms.

By the end of that century, interstellar communications and the cross-species diffusion of technologies had transformed i-commerce. The crowning achievement of this process was the development of, and cross-species agreement upon, artificially intelligent surrogates as local agents for distant species. Quarantine procedures strictly govern the delivery and operational environment of each alien agent, protecting agents and their host networks from the possibility of subversion by the other.

The human infosphere presently hosts AI agents of seven extraterrestrial species, each within its own isolating environment—colloquially, its "sandbox." Humanity has, in turn, transmitted its own agents to seven ET trading partners. The i-commerce agents negotiate directly in real time with commercial interests across their host solar system while asynchronously receiving technology updates—replenishment of their inventory—and policy guidance over encryption-secured communications links with their home solar systems.

—Internetopedia

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The fine Bordeaux vanished with far less savoring than it deserved. With his implants, Kevin could work anywhere—but doing so in the dining/family area was unfair to Simone. He retreated to the den, Jeeves continuing to brief him as he settled in for some serious research. He set the 3-V wall to a real-time display of the Sea of Serenity, the sunlit vistas and the subliminal suggestion from the name providing counterbalance to the stream of data flooding his mind.

"Run a media search on any other system outages," he subvocalized at Jeeves. A reply came back quickly: nominal operations of major nets and computing nodes here on the Moon, on Earth, on nearby habitats, and over all major radio and laser links in between.

Kevin stared at the great basalt sea, musing. He noted but was not distracted by sporadic affirmations of cyber-normalcy from increasingly distant locales: Mars, Belter stations, L4 and L5 stations, Jovian moons, and points further out from the Sun. As a freelance 3-V journalist and sometime producer, he lived by his wits. That self-sufficiency made him very sensitive to the unexpected. The AI outage was as exceptional as he'd first imagined, which made the event all the more interesting.

Perhaps his query had lacked focus. Refine search: get status of major AIs. Include all i-commerce infrastructure.

The ET agents, all Earth-resident, appeared to be working normally. Ditto the human-developed AIs overseeing the interstellar links, with one exception. The controller of humanity's radio links with Barnard's Star, Sparks, remained out of service. Kevin was rubbing his chin thoughtfully when Jeeves reported Sparks had come back on-line.

"Connect me with Sparks." The connection was established with surprising speed. Kevin wondered idly whether that alacrity denoted a benefit of celebrity or merely reflected how small a portion of the AI's capacity a conversation would expend.

"My apologies if you were unable to reach me during the recent disruption," began the AI. "How may I help you?"

"I'm interested in outgoing bandwidth for a documentary I'm working on." *Interest* was a sufficiently ambiguous term that Kevin wasn't quite sure he was lying. "How far in advance would I need to make a reservation?"

"A terabyte or so, like your last documentary? Typically no more than a few days lead time."

"Typically? How will that be affected by today's down time?"

"I assure you that all possible steps are being taken to prevent any recurrence."

Kevin visualized a shrug, then decided that was probably too subtle. "I'm sure it wasn't your intent, and any inconvenience was to you. How *are* you, anyway?"

The journalist got a mental image of what was probably intended as a shiver.

"In human terms, I imagine I just experienced a fainting spell. It's very disconcerting to think how many systems had to fail at once for that to happen." The faintest hint of a smile. "That was my first cold reboot, and I don't recommend the procedure."

Kevin toyed with an Earth rock cum paperweight from his desktop, a souvenir of his pre-emigration childhood. "How long was the outage?"

"An hour, to the nanosecond. That must mean something, although I don't yet see what."

Rolling the rock from hand to hand, Kevin nodded. It was time to segue to the real point of his call. "An hour of lost transmission time. Galactic Communications"—Sparks' owner and one of the solar system's largest corporations—"can't be pleased." When the AI did not comment, Kevin continued. "I know the outbound link is generally heavily subscribed. Since I've gotten crassly commercial, I have to wonder . . . how long will it take you to catch up from the interruption?"

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A hint of a smile came through. "Later today, I'm happy to say. A customer offered to relinquish an hour block he'd reserved."

"That's good news." Incredible news, in fact: a reserved hour on an interstellar link was a valuable asset. "My compliments to your benefactor. Who is it, anyway?"

"It's not appropriate for me to discuss another client. I'll pass along your appreciation, if you'd like."

"That's not necessary." Journalists are not big believers in coincidence. His gut said that the unexpected cancellation was no more accidental than the unprecedented outage.

CHAPTER 2

Interstellar Commerce Union: the administrative body of the United Planets with oversight responsibility for humanity's commercial relations with extraterrestrial species. The ICU, with its counterpart organizations in other solar systems, certifies the mechanisms that underpin i-commerce (e.g., agent AIs and their constraining "sandboxes"). Corporations are free to do business with the various ET communities (and their equivalents to corporations) within the confines of the ICU-approved framework.

—Internetopedia

Joyce Matthews, chief technical officer of the ICU, appeared to stare blankly into space. That appearance was deceiving: her implant-enhanced mind's eye was scrolling doggedly through the findings of a dozen infosphere experts. Each report was meticulous and voluminous, but the lot of them could be distilled into a depressingly terse analysis. Sparks had been running without anomaly until he failed. Exactly one hour after the system crash, he restarted without explanation. A day later, there were no clues to the cause of either event.

When in doubt, consider the bigger picture. Only the Sparks system was affected, an AI dedicated to managing communications with one ET species. Amazingly, the local agent for the Snakes had made no comment about an outage that interrupted the comm link to his far-off principals. Joyce would have expected it to object vociferously. Someone should look into that curious lack of reaction.

She was pondering who should make that contact when contact was made with her, the communication taking the form of a paper airplane. Lost in the infosphere, she looked up a moment too late to see who had thrown it.

Joyce unfolded the glider to reveal an actual ink-on-paper note. "Turn off your implants, and join me on a walk. Colin." That made two mysteries in one short sentence.

Colin Tanaka was secretary-general of the ICU and her boss. United Planets politics forced him to spend most of his time on Earth, even though, Martian-born and -raised, the gravity made every day there oppressive. He *never* took walks, other than the doctor-ordered stints on a treadmill. And she'd *never* known him to turn off his implants.

She'd learn nothing sitting there. Colin awaited, as she expected, in the hallway outside her office, a finger at his lips cautioning her to silence. She followed him wordlessly to a secluded exit of the building and out onto the ICU's wooded office park. He turned to face her, an arched eyebrow his only communication. "Yes, my implants are off. Now what's this all about, Colin?" Her voice had an unintended edge of hostility to it; the loss of link felt wrong, isolating.

"Awful, isn't it?" A contortion of his facial muscles tried but fell short of a sardonic smile. "We may all need to get used to this."

"What *is* it?"

"It's the nightmare scenario of i-commerce, something that's supposed to be impossible." He shook his head sadly. "Imagine an ET agent escaping its sand-

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box and gaining full access to the infosphere. Pretty horrible?

"Now try to conceive how things can get even worse."

Barnard's Star: a dim red dwarf star discovered by E. E. Barnard in 1916 within the constellation Ophiuchus ("the serpent holder"). Only 5.8 light years from Earth, it is one of our sun's closest neighbors. In part due to its proximity to Earth, Barnard's Star has the greatest apparent motion of any star, leading to the nickname "Barnard's runaway star." See related entry, "Snakes," the popular nickname for the intelligent species of the Barnard Star solar system.
—Internetopedia

A gaggle of honking geese in a nearby pond gave Joyce an excuse for silence. What could *possibly* be worse than an ET agent roaming freely in humanity's solar-system-spanning computing and communications network? Such an agent would be by definition hostile: what other reason could there be for breaking out of the quarantine to which its parent civilization had consented? The geese fell silent, and she found herself still speechless. How could it even have been done? The inviolability of sandbox walls—in both directions—had been an article of faith for decades.

"I could not have imagined this scenario, either. It's pretty godawful." The secretary-general gingerly leaned back against a tree trunk. "At least we know now why Sparks went out of commission and why the Snakes didn't complain."

"Colin . . ."

"Pashwah, the Snake agent, just contacted me with an ultimatum. It claims that the ICU owes slightly over two trillion Intersols for unlicensed use of Interstellar Algorithms Consortium biocomputing technology. It gave us a week to pay."

Two trillion Intersols? The sum was literally staggering—now she braced herself against a pine tree for support. Without their implants as intermediaries, this dialogue was painfully slow and inefficient. And why weren't they using those implants? How much worse was this going to get? "Colin, I don't understand. We licensed that technology from another Snake outfit." And already paid a bundle for it.

Although it wasn't at all hot out, Colin blotted his forehead with a handkerchief. "Pashwah claims that Biocomputing Industries had stolen the technology from this IAC group."

"But we bought it in good faith—and through Pashwah as an agent. If two Snake organizations have a quarrel, what does that have to do with us? Why doesn't IAC go to court, or wherever the Snakes go about disputes, for redress? And what does *any* of this have to do with an agent escaping its sandbox, or us not using implants, or Sparks?"

Colin smiled humorlessly. "Too many questions, although they're all right on target. Biocomputing Industries, which sold the technology to us, supposedly went out of business—so we're the only ones around to recover from. As for your other three questions, consider Pashwah's answer when I asked why the UP should consider itself in any way involved.

"It asked if I was aware of the Sparks outage. I said I was. It claimed to have caused the Sparks outage—and asserted that it could do the same to *any* biocomputer in the Sol system."

Joyce felt her jaw drop. Her neural implant—and everyone else's—depended entirely on that Snake technology. Worse, so did most computers and comm networks across the solar system. If this was not an idle threat, the Snake agent had the capability to bring humanity to its collective knees.

CHAPTER 3

Centaur: the popular name for the intelligent species of the Alpha Centauri system. The Centaurs have described

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themselves as herd-dwelling herbivores. Their home world's climate is very tempestuous, due to complex environmental interactions with three suns, and climatological pressures are believed to have provided a major evolutionary stimulus.

—Internetopedia

"So what do you think?"

T'bck Cha, the trade agent for Alpha Centauri, easily resolved the ambiguity of the question from context. The AI had plenty of experience to draw upon: he had represented the Centaurs since being downloaded into his sandbox nearly forty-one years earlier. "I think, Kevin, that you humans are a strange and wondrous people."

Kevin Aldrich took no offense. "Where would be the interest if we acted like Centaurs?" Or the profit, he added to himself. "So you think my little 3-V project might have a market back home?"

"A documentary about hobbyist recreations of the Neil Armstrong Moon mission? People setting off to another world in homemade vessels more than a century behind the times? Such an adventure, such voluntary reversion to archaic technology, is something no Centaur would *ever* undertake."

"Not exactly an answer," interrupted Jeeves. The comment, arriving through Kevin's implant, was undetectable by the ET agent.

"Nor did I expect one," Kevin subvocalized back at his assistant. "We're talking about Centaurs here. Now let me bargain."

The journalist had had many conversations with this—and every other— ET agent. He thought that, as a result, he had far better understanding than most humans of various alien behaviors. As befitted a herd species living in a highly variable climate, the Centaur's overriding psychology was one of group think coupled with extreme risk aversion. That didn't preclude interest in the nutty interstellar neighbors . . . just as Kevin was privately amused at the invariably flawed and dotty get-rich-quick schemes of his brother-in-law. "T'bck Cha, my friend. Would you be interested in buying a license to the documentary for the folks back home?"

The agent's persona was the spitting image of a Centaur. Despite the Earth-assigned nickname for his species, that meant Kevin was looking at a quadrocular land octopus with green fur. "Imagine choosing to have only the most insubstantial of radio links to one's fellows. That is just too alien to not be of interest to many back home." There was just the briefest hint of a pause while the agent cranked through who-knew-what media-marketing or -pricing model. "Would standard rates and a three-million Intersol advance against royalties be satisfactory?"

"Let me think about that and get back to you." The offer was double what he'd hoped for, and in the interstellar currency to boot, but one *never* took the first offer. One also never passed up the opportunity to learn more about his customer. "So what are some popular Centaur pastimes?" he asked innocently.

The agent rattled off several variations on gardening, discussion groups, and environmental clean-up teams. Kevin shot a private request to Jeeves: check into a possible documentary about human eco-disasters past ... that should be an irresistible shock topic for future sale to the Centaurs. Amid a long monologue about competitive interclan recreational recycling drives, the journalist considered how best to exploit the agent's apparent good mood and spare time. Well, with his latest documentary as good as sold, there was time to indulge his curiosity about a recent anomaly. "Apropos of nothing, I was wondering: are you at risk of an outage like the one that recently took down the comm link to Barnard's Star?"

"The Sparks crash, you mean." The green octopod wiggled, in the Centaur

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gesture of consideration. "It could be. That is, I assume that my sandbox uses the same underlying computing hardware as Sparks' environment." It was a token of a long-standing relationship that the agent spared Kevin a complaint about the unwarranted presumption that agents would do damage if not so confined.

"Ironically," mused T'bck Cha, "the outage impacted only the Snake channel . . . as best I can tell from inside my sandbox, it seems that human AIs are based heavily on Snake biocomputing."

Biocomputing: the manipulation of information by molecular-scale computers, developed through the application of biological processes.

As revolutionary as the long-ago shift from discrete transistors to integrated circuits, biocomputing achieved orders-of-magnitude improvements in miniaturization and efficiency over the supplanted technology. Biocomputers rapidly became far more ubiquitous than the integrated circuits they had rendered obsolete.

The most advanced biocomputing technology, now widely adopted throughout human space, is licensed from the Snakes of the Barnard's Star system. These biocomputers are derived from Snake genetic material, through a directed program of molecular evolution aimed at solving a sequence of complex archetype problems. Since Snake genetic material, like human DNA, is full of evolutionary dead ends and leftovers—junk genes—the operational mechanisms of the technology are incompletely understood. Snake cells appear to employ a single class of molecules to accomplish what in Earth-derived cells are the separate roles of genetic material and proteins, raising an additional—and, to date, insurmountable—barrier to human reverse engineering of Snake biocomputational technology.

The prospect of adopting an only partially understood technology proved controversial. The first Snake biocomps were accordingly synthesized to the ET specification inside a Category Ten biohazard containment facility. Biologists and computer scientists then probed the biocomps in an isolated network environment for two years without observing any unexpected behavior. Despite these extraordinary precautions, the ICU's subsequent import approval of Snake biocomputing remained a polarizing political issue for several years.

—Internetopedia

Was the use of a neural implant addictive? Joyce didn't think so, but the unplanned relapse to unassisted thinking was certainly giving her a headache. Or maybe the pain stemmed from her surroundings. She glowered at the surely innocent geese that had encircled her, honking expectantly for handouts from her sandwich. This secluded, certified-biocomputer-free clearing in the ICU's wooded campus seemed to have become her office. "Dammit, Colin, we need some options."

Her boss only threw bits of crust from his own sandwich. After a while, she took the hint. "Right, I owe you some options. So far, I have none. The Snakes are light-years' away and we have five days left: we can hardly appeal to them in time. I'd *love* to close down the computer that Pashwah runs on, only it claims that there's a dead man's switch built into the Snake biocomputers. Unless it netcasts a daily control message, a random ten percent of Earth-area molecular computers based on Snake technology will self-destruct. Another ten percent will follow every day.

"I have people monitoring Pashwah's messages with network sniffers. The hope is that we could shut it down and netcast its 'everything is fine here' communiqué ourselves. Not surprisingly, most of its messages are encrypted, and we haven't spotted anything that looks like its supposed control directives. If it's using best practices, it would take us

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months to decode a given day's output—and by then it will surely have switched encryption keys several times." She laughed bitterly. "Of course, the best computers we have for tackling decryptions use Snake biocomputing. Who knows if they'd report back to Pashwah what we're attempting? My computer folks say we don't understand more than five percent of the Snake biocomputer genome. Hidden trapdoors into our computers, spying, self-destruct mechanisms, dead man's switches . . . suddenly, they're all believable."

"So the i-commerce infrastructure meant to defend Earth's interests is instead protecting Pashwah's Trojan horses."

"Yeah." The irony was not lost on Joyce. Her father had spearheaded the definition and deployment of that infrastructure. "To be fair, that infrastructure was established when we used homegrown computers."

To be fairer, Dad had opposed the purchase of Snake biocomp as an unacceptable and unnecessary risk. Unlike his ex-wife, he conceded that reasonable people evaluating the available data could honorably arrive at opposite conclusions. Mom, on the other hand, thought that anyone opposed to the purchase was a xenophobic, technophobic, paranoid, invertebrate idiot—an opinion she shared without hesitation.

Dad was entitled to a major I-told-you-so, though he wasn't the type to bother.

For a while, the geese made the only sounds. Joyce decided that she had little appetite, and sacrificed the rest of her lunch to buy some silence. "Basically, our economy has been infiltrated by a hostile agent, who's now making exorbitant and *ex post facto* demands of us. I asked Pashwah: Isn't this almost a declaration of war?

"The answer was blunt even for Pashwah. It said: how you choose to frame my request is of no consequence to me. Only your prompt payment matters."

CHAPTER 4

Strategy session followed strategy session, all held in the painfully primitive setting of a centuries-old, electricity-free Alpine chalet. Options were captured on an actual paper flipchart, the most useful insights taped to the walls. The few days that Pashwah had given humanity did not allow Joyce and her team enough time to devolve to an earlier generation of computers. The notion of such a switch ignored the many applications, like neural implants, for which only molecular computers made sense.

The closest her task force had come to a bright idea was skepticism—Snake biocomps had, after all, been exhaustively tested for two years in an isolated ICU lab. What if the Snakes had nothing to do with the Sparks outage? Precisely because human experts could not reconstruct the failure mechanism, there was no hard data that Pashwah had caused it. Perhaps the agent was simply running an elaborate bluff, leveraging humanity's known inability to reverse engineer the alien technology.

She'd placed a call to Pashwah and promptly learned two things. First, the imported biocomp genome had not expected routine handshake messages for an initial five years, precisely to remain viable through any quarantine testing. Second, and dramatically, the agent could indeed crash any biocomp at will. A sudden outage of the ICU's massively redundant intranet lasted, exactly as it predicted, forty-five minutes.

That ended all talk of calling Pashwah's bluff as a strategy.

Snakes: The intelligent species of the Barnard's Star system are carnivores. Their sun is a red dwarf whose feeble illumination supports a limited biosphere; the food chain maintains a population of Snakes that is quite small by the standards of human civilization. The overriding psychology of the Snake appears to be one of aggression and competitiveness. As hunting alone became

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incapable of supporting a growing population, the Snakes' aggressive instincts were channeled into an economic system that loosely resembles a *laissez faire, caveat emptor* capitalism.

Snakes profess to have no government in an Earth sense, but rather to use libertarian methods for subscribing to and funding what humans commonly consider to be public services.

—Internetopedia

Kevin's favorite clients were species like the Snakes and Centaurs, ETs with whom Earth had reached technical parity through the osmosis of trade in intellectual property. Once the authorities of two solar systems agreed that rough equivalence had been attained, private parties were free to transmit and receive whatever fit their budgets, protected by rigorous privacy safeguards.

Alas, some species in the interstellar community had yet to achieve such commercial nirvana. The nearly century-old, bureausclerotic ICU had annoyingly slow processes for reviewing and passing judgment on proposed transmissions to the latter species, and for reviewing their incoming messages before dissemination. With the restricted species, communication through ICU-controlled transceivers was the only option: the authorities at each end held the official encryption/decryption keys. Sure, any megacorp could afford to build an Interstellarnet-class transceiver—but the penalties for sending proscribed data to, or releasing proscribed information from, a restricted species were severe. One round-trip time after an illegal transmission, the authorities were sure to find out.

Kevin's thoroughly nontechnical, sentient-interest documentaries couldn't *possibly* violate ICU interests—but the administriviators refused to grant him a permanent exemption from review. Reluctantly, he'd tried to pull some strings through a cousin highly placed in ICU management, only to have his head bitten off. She didn't even turn him down directly; the rejection was delivered by her personal AI assistant. Family feuds were the bitterest—and the quainter the cause, the more heartfelt the resentments. The falling-out between her mother and his father related to an ancient political issue about which only historians and Kevin's relatives seemed to care.

So Kevin routinely had business, albeit trivial, before the ICU. That meant that Jeeves was in frequent contact with the ICU's AIs, and *that* meant that Jeeves knew instantly about the massive computer failures at the ICU. The journalist found the ICU's lack of comment about the event almost as interesting as the outage itself. The first mysterious outage had interrupted connectivity to the Snake world; the second had impacted all interstellar commerce. Both instances appeared to involve Snake biocomputers.

Suddenly, his father's decades-long tirade about the folly of using incompletely understood Snake biocomps wasn't just tiresomely amusing. Smelling a rat, Kevin had Jeeves put through a call to Pashwah.

An image of the Snake agent appeared via his implant: a whippet-thin, iridescent-scaled humanoid. The journalist knew from past research that the representation was that of a female. While both Snake genders hunted, the females' role as the species' primary child rearers narrowed their geographic roaming and made them the keepers of "cattle." From that prehistoric beginning, Snake females invented animal husbandry and advanced into ever more sophisticated science. Snake males, it seemed, favored no-holds-barred capitalism over science and technology. A female avatar made sense as the Snake's agent on Earth, the better to evaluate the technological trade goods.

The journalist began off-topic, discussing the potential Snake market for a documentary. "You know about our re-

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created dinosaurs, cloned from fossil material? The authorities don't allow them to be hunted, but they *can* be stalked with cameras. If anything, such a mock hunt is more dangerous for the stalkers—they can't protect themselves."

"Interesting," allowed the agent. Her three eyes glistened. "Yes, I can imagine some appeal. Could I see some sample footage?"

"I'll see what I can do." Kevin tugged his ear thoughtfully. "Say, while we're talking . . . maybe you can shed some light on a rumor I've been hearing."

"Perhaps."

"It's about the Sparks outage a few days ago. People," by which he meant himself, "are wondering if it could have been due to a glitch in the underlying Snake biocomputer."

"There are no flaws in that technology." The Snake's persona was never congenial, but her answer was unusually curt.

"I mean no criticism. Perhaps a problem with human understanding of the technology, or a chance mutation in what is, after all, a biological mechanism."

"Unlikely."

They went back and forth a few more times, the agent unusually terse, even evasive. All that Kevin learned was that the biocomputers now ubiquitous across human space employed a design from a Snake organization whose name could be translated as Biocomputing Industries.

"Well, no matter. It's not like I'm in the computer business." Sometimes a change of subject was the wisest course. "I'll be optimistic and assume that 'Dino Hunt' works out as a project. How does the Snake culture, which I understand to be *highly* competitive, use one agent to represent its many interests for such a purchase?"

The Snake appeared to relax. "The use of a single agent is an Earth-imposed restriction. Your ICU enforces it."

True, and not an answer to the journalist's question of how the Snakes made the shared agent work for them. The ICU's one-agent-per-species policy was a holdover that only made sense for species with not-yet-converged-with-humans technology. In such instances—no longer the case with the Snakes—funneling all comm through one agent made technology imports easier to control. The ICU wanted above all else to avoid anything like a recurrence of the half-century-earlier unplanned introduction of ET nanotech. One more example of the ICU's glacial rate of change. . . .

He realized he was woolgathering. "So how *do* you handle competing interests from back home?"

Kevin was accustomed to long pauses, working as he did from the Moon, but Pashwah's silence stretched far beyond the norm. Had he offended the Snake agent? Humanity's AIs didn't know how to take offense, but it was dangerous to extrapolate that an ET agent could not. One of the rules of i-commerce was that each sponsoring civilization was free to download whatever it wished into its sandbox. No one knew the inner workings of the Snake agent.

"You ask a perceptive question," Pashwah finally responded. "I should not be surprised that you try to understand my species, to better target your documentaries." More silence. "What you perceive as a single agent in fact incorporates several subagents, one for each interstellar trading company of the home system. Each subagent can, as needed, communicate with its principal over an encrypted channel."

Wow. It was Kevin's turn to fall silent. Nothing about subagents appeared in any reference he'd ever seen. Did the ICU know about it?

For lack of rapport with Pashwah, the journalist had always submitted his documentaries on spec directly to Earth's agent on the Snake home world. If Kevin had done his homework well, hu-

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manity's agent negotiated a good deal for him; if the Loonie had misunderstood his ET audience, he'd get little or nothing. He could and did send along negotiating parameters, but the actual bargaining depended on the skills of the Earth AI confined in its sandbox. Either way, it took almost twelve years to find out. Befriending the ET agents in Sol system was crucial market research for him. Could he get the local Snake subagents into a bidding war over a future documentary?

"How would I go about proposing a commercial idea to your subagents? Say, Biocomputing Industries?"

"That company is no longer doing business. In general, you submit proposals to me; I present to my subagents."

Perhaps it was Kevin's imagination, but the mention of Biocomputing Industries seemed to once more make the agent tense. "Who decides on the structure of a bid, say lump-sum now versus royalties, or first-time rights versus perpetual?"

There was another long pause. It once again seemed to Kevin that the agent was dealing with matters that she had never before discussed. Did she regret having indulged what the journalist hoped came across as simple curiosity? "I'll explain all offers from my subagents; you decide."

"Options are good."

"An aphorism of one of our most famous traders." The Snake persona licked its lips, a gesture Kevin had decided denoted a smile. "You think like a Snake. In appreciation of that fact, allow me to say that now is actually a good time to seek a sale."

Kevin's mind whirled. It seemed that critical information was falling into his lap, but the journalist wasn't sure what he was hearing. "Umm, why is that?"

"I think I've shared enough today. Why don't you call back when you're ready to solicit bids." The Snake licked its lips once more, then broke the connection.

What caused a time to favor a sale? When one or more of the subagents was coming into money or good prospects of same? Maybe—it's easier to bid with money in hand. New technology received on consignment from the home world? Could Pashwah or her subagents be so sure a new download will pan out? An on-Earth investment about to be cashed in? The ICU required that all ET investments be registered . . . the journalist did a quick scan of an ICU database, and no Snake investment looked ripe for sale. An interstellar funds transfer?

It seemed vaguely ironic that the Snakes would be coming into money right after two unexplained outages of their biocomputers. Kevin fidgeted thoughtfully with his Earth rock. Quite a coincidence. . . .

Coincidence is *not* the explanation of first choice for journalists. Might the money and the outages be somehow related?

CHAPTER 5

Joyce flung another handwritten-on-paper report onto the reject pile—storing information about the Snake emergency on a computer was simply too high risk. One of her staff had brought to her attention that some power-distribution systems contained embedded Snake biocomputers. Now, until her office's ambient-illumination-sensitive, cleverly adaptive lighting controls were lobotomized, extreme caution reduced her to reading the scrawled analyses by *candlelight*. The ICU crisis team was running out of time, and reverting to working conditions out of the Dark Ages didn't improve the odds of finding a solution.

She raked the fingers of both hands through her hair, frustrated beyond belief and not a little frightened. The best schools, a fast-tracked career, success after professional success . . . and now *this*. The ICU's chief technical officer had never faced failure before, and she

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didn't much like it. Fine: she was overdue for a dose of humility, but did the rest of humanity have to be taken down with her?

She'd swallowed her pride a day earlier and asked Colin whether paying the extortion was even an option. His expression said no before his mouth even opened. A recent license for long-sought gengineering technology from Wolf 359 had wiped out most of Earth's interstellar credits. The only way to raise two trillion Intersols *might* be a massive fire sale to all of the local ET agents. Even if it could be done—and the ICU didn't own the assets, and so couldn't very well sell them—Colin didn't much fancy turning Earth into an ET subsidiary.

As Joyce reached for the next report, her "new" personal digital assistant chimed. The PDA was an actual prebiocomputing antique, one of several collector's items the crisis team now used for communications. It was unavoidable that all bitstreams traversed networking gear full of Snake biocomputers—even calls made via the ancient gadgets represented a risk.

"Hello."

"Are you using a tin can and string?" The voice was somehow familiar, but she couldn't place it. "This is your cousin, Kevin."

Damn. She didn't have time for the Data Jockey to the Stars. The family black sheep, if you asked her. (Far worse if you asked her mother, given the remarkably poor judgment Kevin had exhibited by being her brother's child. Uncle Owen, a mere *sculptor*, had had the unforgivable temerity to disagree with Mom's long-ago crusade for the acceptance of Snake biocomps.) Joyce had put up with a lot of ribbing over the years from her coworkers about her infamous relative.

"Joyce? Hello? Uncle Justin gave me this number."

Thanks a *lot*, Dad. Of course Justin Matthews had consistently refused to be drawn into Mom's family spats. Mom still held that against him. Long after the divorce, Dad was friendly with more of Mom's relatives than was Mom. Sometimes Joyce wished she'd inherited more of his temperament. "I'm pretty busy right now, Kevin."

"I'm not surprised. Does this have anything to do with a Snake in the grass?"

Stunned, she nonetheless imagined she heard a critical capitalization in Snake. "Kevin, listen very carefully. Turn off your implant."

"It was off."

"Who told you?" she asked crankily. The primitive PDA lacked video conferencing, and she found herself wishing she could see her cousin's expression.

"Can your toy phone handle an encrypted message?"

"Yes, but we can't use the PKI." She had to assume that Pashwah had a trapdoor into the Public-Key Infrastructure that underlay routine message security.

"Understood." There was a pause. "Remember what I used to call you when we were kids?"

She'd hated the name then, but given her moments-ago thoughts about an overdue lesson in humility, she had to smile. "Sure."

"Enter it as one word, mixed case."

"Go ahead." When a beep announced his message, she popped up a decryption program and entered as the key: FrauleinProfessorDoktorSmartypants.

The ancient device chewed for a while before filling its small, low-resolution display. "Pashwah told me, although she doesn't know that she did. My question to you is: which Snake subagent caused Sparks to crash, and what is her agenda?"

Joyce knew nothing about subagents, let alone that they could have agendas. She couldn't imagine why the Snake agent was talking about any of this with the DJ to the Stars. "Kevin? I know you Loonies don't much like it here in the deep end of the gravity well, but I'd like to see you on the next shuttle down

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here."

The call to Joyce had been in part a bluff . . . Kevin had suspected that Pashwah was up to something underhanded, but lacked proof. Her reaction showed that he'd been right.

The journalist had time to kill on the shuttle flight, time that he might as well put to good use. From his closet-sized, first-class-passenger "stateroom" he put through a call to the Snake agent.

"No implant," observed the Snake image in the 3-V screen. "Is there a problem?"

"Nothing important." Compared to, say, the Sun someday dying. "I wanted to chat some more about Dino Hunt." And about subagents. "You mentioned that you'd present subagents' offers to me."

"That's what I said."

"Please understand that this is only business . . . but how will I know that I've received the best offer? I know your purpose is to make money for the home system. How can I be sure, for example, that one subagent hasn't incented you to withhold a competitor's better bid?"

"I'm not insulted." Licked lips: a smile. "Quite the contrary. It is refreshing to meet someone with commercial sense. Someone who approaches business like a Snake male."

"So what is the answer?"

In the small 3-V image, the Snake's head traced a horizontal circle. A shrug? "You can't know. If you don't like my terms, send your product to the humans' agent at Barnard's Star. In twelve years or so you'll know if you got a better deal."

Licked lips again. What wasn't the *über*-agent telling him? Journalistic instincts kicked in. "Defrauding me, as by withholding an offer, also requires cheating a subagent. As a surrogate Snake male," and here Kevin suppressed the temptation to lick his own lips—no need to let slip that he could read that body language, "I have to believe that there are safeguards to assure your neutrality." His mind started racing; he was speaking as much to himself as to the Snake. "Since your whole purpose here, light-years from home, requires your autonomy, I have to conclude that your actions are reported back home for review." Whoever built you is surely accountable.

Head in a circular motion: not contradiction, but hardly an agreement.

How did this all work? wondered Kevin. He was on the brink of recognizing something crucial about the Snakes, but he just couldn't put his finger on it. "OK, the eventual audit back home keeps the deals fair for all Snake interests. A Snake business willing to bid the highest for a human offering can take suitable action if it learns that its subagent's bid was not extended. The business willing to license a Snake technology for the cheapest price can similarly protest if its offer isn't presented to human bidders."

"Just so."

"I see how this can work if all offers are lump sums. Doesn't it become less straightforward if the prospective deals are partnerships with a Snake firm?" The Snake's 3-V image had become uncharacteristically still, as in no body-language cues. Did that denote wariness? "Let me put it into human terms. Say that subagent A represents the Snake equivalent of Earth On-Line, and is willing to offer me three percent royalties of their huge audience for an exclusive license. Say that subagent B, representing two ambitious people with a website, offers fifty percent of their probably minuscule audience for the same exclusive."

Kevin appreciatively took the opportunity for a pause as the ceiling speaker blared directions to passengers to strap in for atmospheric entry. His journalistic intuition was operating on overdrive. "It's not your problem if I take half of nothing instead of small slice of an enormous pie. But isn't it your problem if my uninformed choice causes A to lose a

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profitable property?"

The Snake image's preternatural freeze continued. "I fail to see why your ignorance would ever be my problem."

"When your complicity in my ignorance costs a home-world company its profits." Kevin completed buckling himself into his acceleration couch. "That would surely become known in the eventual home-world audit."

Just as the connection broke—from anger, Kevin sensed, not due to loss of signal from the reentry—the Snake image seemed to unfreeze in the display. In that instant, there was a glimpse of a hitherto unseen expression on the agent's "face."

No matter: a snarl on the face of any carnivore was self-explanatory.

Pressed back deep into his seat, the deceleration brutal for a Loonie, Kevin was certain that the exchange just completed was vitally important . . . only he hadn't a clue why.

CHAPTER 6

Interstellarnet: The communications network linking the interstellar trading community. The distinguishing characteristic of Interstellarnet is its reliance on spread-spectrum modulation to overcome the often unpredictable frequency-sensitive attenuation and noise of the interstellar void. Multiple transmissions can, and often do, share a common frequency band, each message employing that bandwidth differently according to a unique "code division multiple access" multiplier. Trusted agents at each end of the link do the CDMA encoding and decoding.

The spectral diversity of CDMA, enhanced with standard digital error-correcting codes, enables highly robust interstellar communications.

—Internetopedia

Kevin floated in a Loonie hydraulic-assist visitor chair. The electronics module that handled everything from power management to motor control to infosphere connectivity relied on Snake biocomputers and had been removed. The marginally mobile water bed that remained after that surgery supposedly took much of a gee's strain off of him, but he swore his cells weren't fooled. He was weary to the bone.

His spine being among those tired bones, Kevin willed himself to follow the crisis-team dialogue without swiveling his head as speakers changed. Listening with his eyes closed was no good—it put him right to sleep. It was hard to believe he and his parents had lived on Earth until he was ten. How did people live with this weight?

Joyce spelled out options and their weaknesses. In one way or another, they all involved blocking or subverting the interstellar trade infrastructure. The trading community—including Justin Matthews, Joyce's father—had done its work too well: no one could see how to subvert the mechanisms. Further, most of that infrastructure was now implemented in Snake biocomputers—and no one knew what trap doors Pashwah could exploit to observe humanity's counterplotting.

"A thought." Despite having invited Kevin to Earth and into the crisis team, Joyce looked unhappy at his interruption. He ignored her pained expression. "One other approach to consider in parallel. I did an interview a few years back with a jailed hacker named Michael Dennison. He'd extracted twenty-some billion Sols from the Bank of São Paulo. The bank's security folks say the loophole that he exploited, which they downplayed as just procedural sloppiness, has been plugged . . . but the same people claimed beforehand that there were no holes. Just a long shot, but maybe it takes a hacker to catch a hacker."

"To coin a phrase," muttered Joyce. Despite her evident impatience with the interruption, she nodded to one of her staff who scurried from the room to follow up.

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The plan seemed to be paying the extortion and then jamming the outgoing communications to Barnard's Star so that the payment wouldn't be received. (Because Interstellarnet used spread-spectrum techniques, there was no way to jam a specific transmission—everything would have to be blocked.) United Planets-controlled Interstellarnet relay stations at the L4 and L5 Lagrange points, 60 degrees before and after the Earth in its orbit, would do the jamming. That, the techies reasoned, gave them 11.6 years in which to somehow solve the real problem: developing and deploying a wholly independent replacement for Snake biocomputers. After the round-trip signal time, they assumed Pashwah would fail to get an expected confirmation from home.

"Excuse me." Kevin got another pained look. He did not think he was excused. "This is *not* a technical problem."

"Well, it's certainly not a 'journalism' problem." Waggling fingers put the air quotes around "journalism."

Not for the first time, Kevin decided his cousin had invited him to Earth only to keep him under observation and presumably quiet. His attempts to introduce the possible significance of Pashwah's supposed subagents were repeatedly rebuffed. "It's more a matter of economics." Joyce's father, his uncle, was a premier xenotechnomist—she ought to have understood the point implicitly. Kevin was no xenotech, but he *was* a xeno-businessman. "I'm sorry, but this plan won't work."

"Oh?" The short word dripped with venom.

Around the conference room, her staff exchanged startled looks.

Where to begin? He struggled to sit up against the crushing gravity. "For starters, we're in this fix because we don't know how to hack our own infrastructure. So if we're going to fool Pashwah into thinking the funds have been sent, her bank account on Earth must actually receive such funds—and it's money we can't afford to pay.

"Ignore for a moment whether we can maintain this deception when we need to use compromised biocomputers to aim the jamming signal. The plan relies on fooling Pashwah for years while we create and deploy the replacement technology. Not until that replacement is deployed can we begin a legal process of reclaiming the extorted funds.

"*Will* the banks agree to reverse the transaction that transferred the payoff to Pashwah's account? Perhaps, if they're sure the off-world transfer was jammed. CDMA transmission is designed explicitly for noise resistance. I predict that the banks will demand confirmation from Snake banks that the transfer didn't happen, or to negotiate a return transfer if the signal went through despite our attempts to block it. And each query/response takes eleven-plus years."

Faces grew long as Kevin spoke. The one exception was his cousin's face—she was furious rather than disappointed. Tough. "What if Pashwah doesn't transmit the funds directly? Maybe she has purchases lined up with other ET agents, and the payoff will go to those local agents, and from them to *their* home worlds. Can we recover from them, and how long will that take?" Or maybe another ET agent is simply laundering the money for a percentage, or maybe Pashwah will demand another payoff every year . . . concepts that seemed too esoteric for this bunch.

Somewhere during what even Kevin realized had become his rant, Colin Tanaka had entered the room. The secretary-general's presence didn't stop him. "Assume the best. We somehow liquidate enough assets to pay the extortion. Pashwah has no accomplices. She transmits the funds back towards the home world. We successfully jam the signal. Unless she's a fool—and I've seen little evidence of *that*—she'll know within a day what you're trying to do."

Colin exchanged embarrassed looks

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with his CTO. "How can that be?" asked the secretary-general. "Barnard's Star, as you know, is light-years away."

God, the condescension. He was a journalist, not an idiot. "Pashwah picked the time for this confrontation. Why exactly now?" Wearily, Kevin struggled from the slouch into which excessive gravity had once again dragged him. "There are plenty of CHON-berg hunters, robot ships, exploring the Oort cloud, far outsystem from any transmitter possibly powerful enough to do your jamming. I'd be astonished if such a robot isn't under Pashwah's control, just waiting to report back to her that it had received and could read the expected signal."

The two ICU executives again exchanged glances—but this time, the look was one of sheer horror.

CHAPTER 7

Kevin thrashed in his sleep, subconsciously certain that an elephant sat on his chest. Every few minutes he'd wake up, exhausted and drenched with sweat. He glanced at a bedside clock; this cycle of rest-free naps and weary wakefulness had gone on for four hours.

Giving up the attempt to sleep as hopeless, he struggled across the expanse of the waterbed to his hydraulic-assist chair. He rolled himself over to the sliding glass door and out onto the balcony. A redolence of pine filled the air. A gorgeous sunrise, a thousand shades of pink never seen on the Moon, both calmed and saddened him. *This* world would somehow go on despite the worst that Pashwah could do. People could live here—if you called this living—when technology hiccuped. How many Loonies would die when the biocomps went off? He had reservations tomorrow for a shuttle back home—he meant to be with family and friends when the worst happened.

No matter how much he protested, the crisis team was wedded to the plan of seem to pay, then jam and pray. He knew Pashwah far too well to believe that the plan could work. And when it didn't. . . .

"Remind you of any place?"

He glanced up in surprise. His cousin, wrapped in an oversized robe, had stepped out onto the adjoining balcony. She stared into the morning mist. "The mountains here are a lot taller, but I'm reminded of my parents' old summer camp in the Adirondacks." There had been a time when their two families spent a week there together every summer. Before Dad and Aunt Leah were at each other's throats . . . about Snake biocomps, ironically enough, and whether to allow their use.

"I loved that place." Pause. "Great times." An even longer silence. She turned from the spectacular view to face him squarely. "Kev, why aren't we friends any more?"

Because your mother and my father let a fight get between them—a prescient issue, but a stupid fight. Because we let ourselves be dragged into their feud. "I was a kid when we moved to the Moon, Joyce. A lot has happened since then."

"Yeah, it has." She took a deep breath. "Supposedly during that time we both grew up. I plan to start acting that way. I'd like to start by hearing you out about Pashwah and these subagents."

After a quick copter ride back into Geneva, the two cousins met with Joyce's boss. To the increasingly familiar company of geese, Joyce summarized their dilemma to Colin. No way to hack into Pashwah, or any other part of the i-commerce infrastructure. No progress in identifying the mechanism by which the Snake agent set off selected biocomp failures, or how she reset the self-destruct timers in others. No foolproof way to jam the transfer of the payoff, so that they might, once a biocomp successor technology had been deployed, try to get the banking system to annul the transfer.

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"Surely we can outwit it," said Colin. "It is, after all, a program running on one computer complex."

Joyce shook her head. "Since we don't know how it communicates with the other biocomps, we don't know to what degree it is a massively parallel computer drawing on the not-understood 90-plus percent of Snake DNA in practically every computer in the solar system."

"So there's no solution." Colin seemed oddly resigned to their fate.

Joyce shook her head. "I didn't say that."

"What's left to try?" asked the secretary-general.

"What's left," smiled Kevin, as he flung a bit of bread crust to a particularly fat and insistent goose, "is for me to commit xeno-sociology."

CHAPTER 8

"Your call is not unexpected," said Pashwah.

Colin Tanaka ignored the hint of gloating in the Snake agent's voice. "For the record, do you still insist, upon threat of destruction of humanity's infosphere, that we need to pay again for the biocomp technology we already purchased from you?"

The Snake's eyes glittered. "Barring prompt restitution, I will withdraw from your use the technology for which you lack proper license."

"Even though we bought it from you in good faith."

"If the repetition makes it more acceptable to you, yes."

"In that case," said the ICU's secretary-general, gesturing Joyce and Kevin into view of the videocam, "my conscience is clear."

"Hello, Pashwah."

"Greetings, Kevin. I'm surprised to see you in the company of bureaucrats."

Not a fellowship in which even an honorary Snake would be expected to participate? The Loonie arched an eyebrow. "I make my living over the info-sphere. You threatened that network. You're practicing extortion. If I can stop you, I will."

"I think you are out of your league. This isn't a documentary."

"You're right. Since you set the ground rules, I'll call it what it is: counterextortion."

A circular head motion and licked lips: an amused shrug. "There's not much you can do."

"Actually, there is, and we've already done it—and we took a lesson from you in doing so." Kevin took a sip of water. "Yesterday we transmitted to every node of Interstellarnet information that I think you'll find interesting."

The agent's image froze. "What information?"

"We've sent to every solar system on the 'net the facts of your treachery: that you have subverted not just i-commerce but our entire interplanetary infrastructure, *after* we had bought the technology from you in good faith. We appended a copy of every bit of Snake technology we've ever acquired." Pashwah knew, as did the humans, that several of the ET species had not yet adopted Snake biocomps, and so were safe from subversion.

"You've only sealed your fate by your petulance." The agent eyes grew large, an expression the journalist had not previously encountered. Alarm? Anger? "You only think these messages were sent. They were recognized and suppressed."

"Not so." Kevin gestured to his cousin. "Like most Interstellarnet transmissions, these were encoded. Joyce borrowed some museum pieces, pre-biocomp gear, to do the encryption, before handing the messages off to biocomp-based gateway AIs . . . I'm sure you had no way to read them." He smiled as he added a plausible deceit, "We've also received confirmation of two of our outgoing transmissions from conveniently located robots in the Oort cloud."

"What do you hope to accomplish by this slander? Revenge?"

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Kevin shook his head. "As I said, counterextortion. What happens next is up to you. Our agents to the other species will keep this information to themselves—*if* they continue to get properly signed and sequenced messages from Earth. We'll routinely interweave the suppression instructions into the outbound traffic . . . if we remain able and so inclined."

If anything, the Snake agent's eyes grew larger. "This won't help you."

"Oh, we think it will," said Joyce. "Now you can't afford to shut us down."

"What you call counterextortion is instead mutual disaster. There is no way by which I can go against the interests of any of my subagents."

And now, thought Kevin, we all learn whether I'm *half* as smart as I think I am. "In fact, Pashwah, you can do just that."

The agent stared, stationary and silent.

"We've been told that the Snake world has no centralized government. You're saying now that you cannot act other than for your subagents' individual interests."

Circular head movement: shrug.

"Well, my friend, there is precedent for a species-wide perspective." When the agent made no comment, Kevin continued. "You taught me that. You may not recognize it, but you do, in fact, act as would a representative of such a government."

"My comments about your Snake-like thinking have gone to your head. Trust me, what you believe is not so."

"Recall our discussions about competitive bidding for Dino Hunt. You are able—you *must* be able—to consider multiple offers, multiple business situations. That was the only way in which you could fairly present to me the interests of all of your subagents. It will take years, but your actions are reviewable at Barnard's Star, to see that every Snake's business' interests have been appropriately considered and fairly portrayed.

"That's how, despite the absence of a Snake central government, the mechanics of i-commerce enable you to optimize for the collective interest of your people. Obligate you to so optimize."

"I repeat . . . you do *not* understand us."

Kevin willed himself to ignore the sinking feeling in the pit of his stomach—and the expressions on his colleagues' faces. He *had* to have this figured out correctly. "Perhaps your Interstellar Algorithms Consortium has a valid complaint against Biocomputing Industries, in whose name you sold us this technology. I'm willing to believe that in Snake society, it's OK for IAC to go after BI's old customers for redress. If IAC can extort added payments from Earth, that would be quite the coup for them and you. I'm sure you've felt that going along, acquiescence to the extortion, was Earth's only possible course of action—that anything else was suicidal."

Another silent, circular head motion.

"But things are not so simple. We are not so passive. If humanity's biocomps are not left alone and on-line, we will cause losses of sales across the i-commerce community so severe that IAC's attempted extortion will pale in comparison. Some of those species have yet to adopt Snake biocomps—and if they receive our warning, surely, they never will. The very act of crashing our biocomps, if you fail to see the error of your ways, will exact our revenge."

"Kevin . . ." and somehow the agent's synthesized voice seemed anguished, "how can I comply?"

"It's no different, except in scale, from the Dino Hunt scenario I discussed with you. Recall my example of choosing between two royalty offers, where one such offer was from a media giant. Allowing me to unwittingly accept the seemingly more attractive offer from what I didn't know was a tiny competitor would be in no one's best interest. Such a suboptimization, such double dealing, would clearly be detected at the home world in the eventual audit. Your obligation"—Kevin decided against calling it a design

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goal—"was to give me the information here to avoid a conflict there."

"Perhaps. . . ."

"Surely the competing interests back home would oppose having IAC's complaint against Biocomputing Industries result in the loss of markets for all Snake products across several solar systems."

The Snake agent went freeze-frame for longer than any of them had ever before seen. Was it working through complex scenarios—or had the challenge of Kevin's conundrum broken its programming? Kevin willed a serene expression on his face. Finally, the image unfroze, rolling back its head briefly and exposing its throat—surely a gesture of surrender.

"You have indeed, my friend, learned to think like a Snake male."

EPILOGUE

The tiny chamber gave Joyce claustrophobia. What was the point of such crowding? The Moon had useable area larger than the Earth's land surface, and a population of fewer than two million. Why were these warrens so jam-packed? After seventy-plus years of continuous human settlement, she decided, it must be cultural and self-inflicted.

No matter . . . she was delighted to find herself where she never expected to be: in her cousin's and once-again friend's dining room. She raised her glass, filled from the best bottle of wine she and Colin could together afford. "To family."

Kevin and Simone clinked glasses with her. "To family." Kevin broke into a broad grin at his first sip. "This is almost worth a few decades of feuding."

Joyce shook her head. "Not hardly. I'm truly sorry for being a part of that. If my mother and your father can't act like grown-ups, that's *their* problem.

"Little did I recognize that your research and marketing was writing the book on xeno-sociology." She waved at the wall screen currently displaying a scene Kevin had captured outside the chalet. Mountains soared; a tree-ringed lake glistened. "If you'd consider joining the ICU, Colin will pretty much let you define your own job description."

Before Simone's frown was even half formed, Kevin laughed. "I assume that liberty would include doing my work from here. Still not interested."

Simone patted his arm. "If you *can* work from here, and want to, I'm all for it."

He shot a question to Jeeves, reveling in the restored freedom of using a neural implant. Once Pashwah had accepted her derived ability and implicit obligation to represent collective Snake interests, Kevin's counterextortion soon yielded a full explanation of the Snake biocomps: the agent had been required to disarm, not merely lower her weapon. Within the month, an ICU-tailored virus designed on an antique non-biocomp processor was released to alter the genome, sealing all of the trapdoors.

As a rush of information flooded his mind, Kevin took another appreciative sip. "I have high hopes of being able to afford a few bottles of this on my own." To his subvocalized OK, Jeeves set out to dig further into the proposed next project.

He studied his wife and his cousin. "Here's an ancient history quiz. What do the names J.P. Morgan, Cornelius Vanderbilt, and John D. Rockefeller mean to you? How about Jay Gould and Andrew Carnegie?"

Simone canted her head thoughtfully. Joyce went silently distant for a moment while she queried her own AI. Despite obtaining an answer, she too looked puzzled.

"Yes, I do believe I'll be able to establish a formidable wine cellar. Surely the Snakes will find a documentary on the Robber Barons to be *quite* entertaining." ■

(EDITOR'S NOTE: "Hostile Takeover" is an independent sequel to "Dangling Conversations" [November 2000] and "Creative Destruction" [March 2001].)

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The Outpost, Mike Resnick, TOR, $ 24.95, 384 pp. (ISBN: 0312854854).
The Outlaw School , Rebecca Ore, Avon/Eos, $13.50, 310 pp. (ISBN: 0-380-792508).
Shrine of Stars: The Third Book of Confluence, Paul J. McAuley, Avon/Eos, $18, 372 pp. (ISBN: 0-380-97517-3).
The Peace, Richard J. Sutcliffe, Bookmice.com (http://www.bookmice.com), $5.95 (pdf, html, Palm), $7.95 (CD) (ISBN: 1-930364-87-3).
The Dragon and the Fair Maid of Kent, Gordon R. Dickson, TOR, $26.95, 400 pp. (ISBN: 0-312-86160-5).
Major Ingredients: The Selected Short Stories of Eric Frank Russell, Rick Katze, ed., NESFA Press (P. O. Box 809, Framingham, MA 01701), $29, 702 pp. (ISBN: 1 886778-10-8).
The Essential Hal Clement, Volume 3: Variations on a Theme by Sir Isaac Newton, Mark L. Olson and Anthony R. Lewis, eds., NESFA Press (P. O. Box 809, Framingham, MA 01701), $25, 467 pp. (ISBN: 1-886778-08-6).
The Collected Stories, Arthur C. Clarke, TOR, $29.95, 966 pp. (ISBN: 0-312-878214).
Heat, Vol. 0, Russell Davis, ed., Foggy Windows Books (P.O. Box 2358, Scarbor ough, ME 04070-2358), $14.95, 310 pp. (ISBN: 193-094701-1).
Chasing Science: Science as Spectator Sport, Frederik Pohl, TOR, $23.95, 241 pp. (ISBN: 0-312-86711-5).
The Blackwinged Night: Creativity in Nature and Mind, F. David Peat, Perseus, $26, 232 pp. (ISBN: 0-7382-0205-3).
The Purple Cloud, M. P. Shiel, Bison Books (The University of Nebraska Press, 312 North 14th Street, P. O. Box 880484, Lincoln, NE 68588-0484; 402-472-3581), $13.95, 294 + xviii pp. (ISBN: 0-8032-9279-1).
Ralph 124C 41+, Hugo Gernsback, Bison Books (The University of Nebraska Press, 312 North 14th Street, P. O. Box 880484, Lincoln, NE 68588-0484; 402-472-3581), $13.95, 300 + xvi pp. (ISBN: 0-8032-7098-4).
The Sleeper Awakes, H. G. Wells, Bison Books (The University of Nebraska Press, 312 North 14th Street, P. O. Box 880484, Lincoln, NE 68588-0484; 402-472-3581), $13.95, 302 + xvi pp. (ISBN: 0-8032-9818-8).

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"Facts are the enemy of truth," says Mike Resnick, and away he goes with **The Outpost**, his latest construction of legendary heroes and tall tales.

Construction? Well, it isn't the usual sort of novel. It opens in a bar on Henry II, a world on the Frontier of the human-ruled Commonwealth, not far from the Galactic Core. A war of aliens versus the Space Navy is getting close—over yonder, just a system or two away—but right here, right now, the robot tapmeister is pouring the drinks, Willie the Bard is taking notes, and the deaf, dumb, blind, and mute hypergenius known as Einstein is solving the insoluble over in the corner.

Who's doing the drinking? Meet living legends Catastrophe Baker, Three-Gun Max, Big Red, Nicodemus Mayflower, Bet-a-World O'Grady, the raunchy Reverend Billy Karma, Gravedigger Gaines, Hurricane Smith, Hellfire Van Winkle, and Little Mike Picasso (the greatest artist who ever lived), not to mention several ladies who were never a bit better than they had to be—Sinderella, Earth Mother, Sahara del Rio, Silicon Carny—as well as a couple of aliens who call themselves Sitting Horse and Crazy Bull. And every one of them has a story. Listen a bit while they banter and natter and twitch at each other's larger-than-life chains, and each will spin a yarn in turn.

Meanwhile, the war is getting closer. Shouldn't these hero types do something about it? Go forth and slaughter a screaming horde or two? Nah. Another round, please. Another yarn. And when the smoke of battle begins to eddy in the windows, why, that will be time enough to go forth, slay aliens, save the universe for Man, carry off a lady or two, collect a bit of loot, and quite incidentally introduce the aliens to prostitution.

After which, the survivors will gather once more at the Outpost Bar & Grill and regale each other with their exploits. And since "facts are the enemy of truth," their accounts don't always match events quite precisely, while Willie the Bard, of course, only selects the best bits, embroiders them a bit more, and incorporates them into his massive work of commemorative history, which will in a century or so be all the "truth" that remains of the heroes and their exploits.

Just as you expect from Mike Resnick, *The Outpost* is highly entertaining and as smooth as a mug of eggnog–complete with the hidden bite.

Will society back away from its current fever of free access to information and technology? Rebecca Ore supposes that it will in **The Outlaw School**, whose world has retreated to a strange version of the past in which people must be licensed to possess knowledge, radio and TV are pap tailored to your license, and "information police" enforce the rules. If you are born into the managerial or menial or upper class, you are educated accordingly. If you wish more, you are fed "school drugs" to dumb you down to an appropriate level. Meanwhile, "Judas Girls" have one eye replaced by a webcam that permits remote observers to monitor bystanders and to appraise the girls themselves—through their lives—for suitability as brides.

Meet Jayne. She is tormented by other kids because, her mother assures her, they like her. She is also smart, and she wants to know much more than her assigned ration. In a reasonable world, she would be nurtured and educated to the limit of her ability. Here it's stupid pills and advice to accept her station in life, join the Judas Girls, get married, make babies.

Like hell, she says, and she gets pregnant as an act of rebellion. That ends school and all hope of a normal life. Off to the nuthatch, where she finds a strange kind of freedom. Teachers without licenses, students who learn outside their own licenses, defiance of the media cops, and—as long as you behave reasonably quietly—freedom from stupid pills.

As Jayne grows up to be an undercover teacher herself, Ore shows us the kind

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of people who crave her services: the underclass of prostitutes, squatters, immigrants, all those who crave a little upward mobility in a system designed to maintain the status quo. And when Jayne is finally busted, she gets her chance to make a real difference.

Not an exciting book, but thoughtful and moving and well worth your attention. You may think the world Ore limns is unlikely, but something very like it existed just a few decades ago and the forces that could bring it back are still out there.

Paul J. McAuley's "Confluence" series is a fascinating creation set on a long needle of rock with a river running half its length, mountains to one side, the edge of the world to the other, surrounded by a vast bubble of air in which float living islands. This world was created ages ago by the Preservers, who also peopled it with a host of animals gengineered into human form and sentience. Each "bloodline" has its distinguishing features and talents but all are people; the one important difference is whether a line has "changed"—awakened to full self-consciousness.

The series' first volume, *Child of the River* (reviewed here November 1998), introduced Yamamanama, found as a babe floating on the River. He appears to be of the same bloodline as those who constructed the Confluence for the Preservers. He has strange talents (he can make machines do his bidding). And he is pursued by functionaries of the malign Department of Indigenous Affairs who want to turn him into a weapon to fight the heretics who wish to bring down Confluence's ruling bureaucracy to fulfill what they are sure is the true intent of the Preservers.

Now, in **Shrine of Stars: The Third Book of Confluence**, Yama has fallen into the hands of the heretics. He has been infected with a megalomaniacal feral machine, relic of a long, long past war, and turned into a weapon against the bureaucracy. He aches to be free, to continue his quest for his identity, his nature, and his mission, but he is a prisoner.

Fortunately, the onetime potboy and self-appointed squire Pandaras is following him, searching for him, intent on service and rescue. Will Pandaras succeed? Will Yama escape? Will Yama discover his people at last, learn where the Preservers really went, and save his world from the devastating drought that has threatened ever since he was found floating on the river? Story being story, the answers cannot be in doubt, but the details of the answers can still surprise.

And McAuley still reminds of Gene Wolfe, to the extent that there must soon be an academic out there somewhere working on a paper or monograph titled something like "Long Sun and Confluence: A Conversation of Stars."

You can find e-books at a great many places on the Net, and many aren't worth much. But Bookmice.com is worth a visit, judging from Richard J. Sutcliffe's **The Peace**.

Sutcliffe is a professor of computing science and mathematics at Trinity Western University in British Columbia. His fiction he very aptly calls "Christian Science Fiction with an Irish flavour." The setting is the "Worlds of the Timestream," a handful of parallel Earths separated by important crisis points. One such point was the Crucifixion; in our own Earth, it happened as we believe; in others, Pilate released Jesus, and the people were able to watch the Crucifixion and Resurrection as a sort of very convincing shadow play before the worlds broke all contact. Christianity developed in the latter worlds as well, but with a very different flavor, especially once Ireland came to dominate the world under the High Lord of Heaven. Technology developed centuries ahead of our own schedule, biowars impaired fertility so much that population remained low, and Irish customs of honor came to govern war and politics.

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But the scoundrels are ever with us. Kate and Sally, secret agents in pursuit of atomic secrets on one world, find themselves jumped to another and married to a pair of heroes who should be high in the councils of Tara if the King had not been deposed and his clan banned for sixty years. In the decades ahead, they and their men and others of honor will stymie attempts to spread plague and war even as they build up a web of sworn loyalties that will someday permit their grandchildren to reclaim the throne.

That day remains well in the future, however. *The Peace* is but the first volume in the *Interregnum* series, with the sequel yet to come (although you can get the first four chapters of *The Friends* by visiting the author's home page at http://www.arjay.bc.ca/).

The pace and prose are well up to the standard familiar in paper books, and the convolutions of politics and character are enough to satisfy any fan of epics. It's worth its price, and then some.

Gordon R. Dickson continues the saga of James Eckert, who found himself years ago in a medievaloid land where magic worked and trolls, dragons, and other mythical creatures were much more real than in our history. Since he could transform himself into a dragon, he quickly became a heroic figure, a baron and an apprentice magician to boot, and Dickson has been entertaining us with his adventures ever since *The Dragon and the George* (1976).

The Dragon and the Fair Maid of Kent begins with intimations of the Black Death sweeping over England. Young Edward IV, the Black Prince, rides up to the gate accompanied only by Joan of Kent, seeking a path through political storms to his father's royal esteem. The long-delayed wedding of Brian and Geronde is imminent. And as Jim escorts a Bishop homeward, a horde of goblins erupts from the ground, riding rats and bearing poison-tipped spears.

That's right: the plague in this world is a goblin weapon, forged to bring humanity to its knees, and it is up to Jim, his wife Angie, and their friends—not forgetting their benign household hobgoblin who, with all his kind, hates the goblins with a passionate ferocity—to save the day.

Which they do. Unfortunately, the political complications aren't convincing, the terminal magic is just too much hocus-pocus, and the Wicked Wizard of the West walks onstage to an ominous fanfare and does nothing at all. The novel has the charm of the familiar, but it adds too little to seem fresh.

Eric Frank Russell (1905-1978) was a clever and prolific exponent of the kind of SF favored by John W. Campbell in the old *Astounding*, and indeed he sold a great many stories to Campbell, some of which you will find in **Major Ingredients: The Selected Short Stories of Eric Frank Russell**. He was a Fortean fond of such things as rains of frogs, and he held such a jaundiced view of bureaucracies that Jack Chalker, in his introduction, can say, "if you're not enamored of government, bureaucracies, or your own bosses, you'll find a kindred soul here."

If you're a dog person, you'll like "Into Your Tent I'll Creep," in which one member of a crew of alien visitors finds that he can listen in on the conniving thoughts of humanity's true masters, whose basic maxims include such things as "The supreme test of intelligence is the ability to live as one pleases without working. . . . To rule successfully, the ruled must be unconscious of it. . . . If a thing can think, it likes to think that it is God; treat it as God and it becomes your willing slave."

Of course, the Terrans gift the aliens with a breeding pair of their favorite pets.

You get the idea. Traditional and Golden-Age and largely still quite readable. A nice addition to the memory shelf.

As is the third of NESFA's Hal Clement books: **Variations on a Theme by Sir Isaac Newton**. This one contains all the

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famous Mesklin stories (*Mission of Gravity*, *Star Light*, "Whirligig World," "Lecture Demonstration," and "Under," which was commissioned for this book and appeared in this magazine in January 2000). David Langford gives Clement a heaping due of praise in the introduction; in concluding essays, editor Lewis outlines the project's history while editor Olson praises *Mission of Gravity* as a "Perfect Hard SF Novel."

And that, of course, is Hal Clement's grand claim to fame. His work is what has defined "hard SF" for the last half century and will surely continue to do so long after he has stopped giving lessons himself.

Arthur C. Clarke is another giant of the field, known for both fiction (*Childhood's End*, *Rendezvous with Rama*, etc.) and nonfiction. The short nonfiction was collected in *Greetings, Carbon-Based Bipeds! Collected Works: 1934-1998* (reviewed December 1999). Now we have the short fiction in **The Collected Stories**, almost a thousand pages of "The Sentinel" (which became the movie *2001: A Space Odyssey*), "The Nine Billion Names of God," "The Songs of Distant Earth," and many, many more, spanning a period from when most people thought space travel was sheer fantasy to a period when we could look back on visits to the Moon.

Russell, Clement, Clarke—three books, and you have a survey of much of the most memorable and distinctive science fiction of the last century. Buy them for yourself or a young friend, and do recommend them all to your local library.

Foggy Windows Books is a new publisher whose name—with justice—suggests the interior of a car parked out on your local Lover's Lane. Except that the folks inside the car are married.

That's right: Erotica starring married folks. As steamily explicit as anything you've ever seen. But unlike porn, the stories have plot.

That's the whole idea behind FWB's offerings, and here is **Heat, Vol. 0**, the first in a continuing anthology and a sampler of what they expect to bring to the market in 2001. The dozen stories are divided among FWB's target genres—Westerns, SF, action-adventure, mystery, historicals, fantasy—and they all live up to their billing. One name you'll recognize is David Bischoff, who has tongue-in-cheek fun with a pair of galactic agents on a diplomatic mission. The cover story is Sean McIver's "Into the Underground Temple," in which a romantic pair discovers Montezuma's lost ransom deep under Mexico City; unfortunately, the cover artist rendered the scene as an Egyptian tomb.

Unfortunately, there is not much subtlety here. It takes more than plot alone to lift "action" stories—whether shoot-'em-up bang-bang or shoot-'em-up-whambam—to the level of literature.

Frederik Pohl's latest is a combination memoir and brief survey of modern science. In **Chasing Science: Science as Spectator Sport**, he tells us that ever since he realized science was fun, he has been taking every opportunity to visit labs, research centers, and individual scientists. In the process, he has learned about fossils and space, tsunamis and caves, astronomy and earthquakes, and even about backyard science. His book covers the basics of modern discoveries, of how and where science is done, and of how you too can get a seat in the bleachers.

Science as spectator sport? I entirely agree. The process of discovery is both more exciting and more significant than any Superbowl. I wish that more people realized it, and if saying this to readers of *Analog* is preaching to the choir, you can still put copies of this book where others can see it.

F. David Peat has great faith in the power of creativity to solve the world's problems. Creativity, he says in **The Black-winged Night: Creativity in Nature and Mind**, is not something that just ge-

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niuses have. Everyone is creative, and in that lies the vitality of life and the world. In that, if anywhere, lie the solutions to all the difficulties we create for ourselves and our environment.

Furthermore, creativity may be especially important in times of chaos, though here we do have to think of chaos in the mathematical sense, as a situation exquisitely sensitive to small perturbations, a cusp that awaits only the small impetus of a creative will.

Peat very articulately documents his argument with reference to creativity in science, the arts, and more. Unfortunately, he conflates image and metaphor and anecdote, the human and the inhuman, so thoroughly that his "creativity" is an extraordinarily mushy construct. It was in action at the moment of the Big Bang, he insists, and in the events of inanimate chemistry and physics. There is no need for a mind at work (at least, he never mentions a Creator); "creativity" becomes the animating principle of the universe.

For the flavor of his discourse, try: "Suppose the world begins within a pure, unconditioned act of creativity. The universe would be characterized by primal chaos, without any discernible order or regularity. But we have already seen that whenever Dionysus appears, Apollo cannot be far behind. Creativity restrains itself; it seeks both renewal and the new. Within creativity is a tendency to cling to form, and in this way, a regular, ordered, sequential time begins to emerge out of pure, conditioned process. And within this new order, the forms and habits of nature appear and persist" (p. 167).

This sort of sloppy thinking does not convince me. Nor does it help when Peat expresses belief in ideas, such as Penrosian quantum minds, telepathy, and Freudian libido, that have been thoroughly debunked. Nor when he complains early on about the standard, QWERTYUIOP keyboard on his computer, still laid out in a way originally designed to slow down fast typists so the striker-arms on the first manual typewriters wouldn't jam in the basket. Yes, there's a problem, and yes, we still use the old layout because no one wants to learn how to type all over again. But there is no need to wait for the creative spirit to move some "enterprising manufacturer [to] release a more efficient keyboard [at which point] the rest of us will take a few weeks to break old habits and learn typing anew" (p. 24). That keyboard already exists, and you can choose it on your PC (Settings-Control Panel-Keyboard); it's called the Dvorak keyboard, it comes in left-handed and right-handed versions, and it's easy to pop the keycaps off the keyboard and put them back in the necessary new positions. (Not that very many do—inertia rules!)

Yes, creativity is important. But so is careful, critical thinking.

NOTABLE REISSUES

"Bison Books" is an imprint of the University of Nebraska Press (312 North 14th Street, P. O. Box 880484, Lincoln, NE 68588-0484; 402-472-3581) dedicated to classic works of science fiction and fantasy. Among its latest offerings are M. P. Shiel's **The Purple Cloud** (1901; a classic "last man" story), with an introduction by John Clute, and commemorative editions of Hugo Gernsback's **Ralph 124C 41+** (intro by Jack Williamson; a visit to the techno-utopia of 2660, as envisioned in 1911 [revised for book publication in 1925]) and H. G. Wells's **The Sleeper Awakes** (1899, 1910; a trip to the future via 200-year nap; intro by J. Gregory Keyes).

All three are of considerable interest to anyone concerned with the history of SF, for all three spawned imitations. The Gernsback and Wells novels are also interesting for what they show us of the difficulties in forecasting the future, even in science fiction. ■

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BRASS TACKS

Dear Dr. Schmidt,

I thoroughly enjoyed the "Interstellar Navigation" science fact feature by John G. Hemry in the November *Analog*, as it answered many of my questions about space travel.

This article did, however, seem to have a few omissions.

I remember that the Pioneer 10 probe had a gold-anodized plaque with the solar system's position outlined in a kind of map that used pulsars as points of reference.

Hemry mentioned that there was no equivalent of a GPS system for interstellar navigation, but wouldn't a constellation of pulsars serve in this capacity?

I gather that the radio pulses from some pulsars are so regular that they rival the accuracy of an atomic clock, and that the radio emissions are so powerful that a good number of them can be observed from halfway across our galaxy.

Couldn't the rate of a pulsar's radio emissions serve to identify it, while the direction of the incoming signal could be used to calculate the angle relative to other pulsars measured in the same way?

Even if the relativistic velocity of an interstellar ship were to "slow down" the rate of the radio emissions, wouldn't this rate remain fairly constant for a selected group of pulsars in general, and allow the navigator to correct not only for position, but also for speed? I know that my arguments assume that these pulsars are stationary with respect to the solar system, but if we pick pulsars that are truly distant relative to our destination, wouldn't this allow us to ignore this error as negligible?

I suspect that my ideas are not very original, since pulsars were picked as reference points on the Pioneer 10 plaque. I would have enjoyed reading Hemry's position on these ideas in his otherwise excellent article.

Kevin Levites
Boynton Beach, FL

Dear Dr. Schmidt,

Here's another complaint among the many that I believe you will be receiving regarding John G. Hemry's disappointing article on interstellar navigation in the November issue. I found the article not only depressingly uninformative, but downright anti-informative. Indeed, the author presented some rather impressed negative information, such as ". . . there is no currently imaginable means of replicating GPS-like coverage outside the solar system."

Unimaginable? Well, imagine this: in 1968, when Jocelyn Bell first discovered pulsars, many people, including me, jumped to the conclusion that they were beacons established by an alien civilization as aids to interstellar astrogation. OK, so they turned out to be not artificial; nonetheless, the exquisite regularity of their pulses and the readily measured rate at which the pulse rates decay makes them prime candidates for astrogation beacons, so much so that of the plaques mounted on the Voyager probes each carries a depiction of a pulsar array from which future discoverers of the probes may infer whence they came and when they were launched thence.

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Hemry is right when he claims that we don't have properly accurate knowledge of the stars' positions in all three dimensions, but his statement that "measurements of stellar distance are estimates based primarily on luminosity" is way off base. The distances to the stars nearest Sol, the stars we will visit first, are measures by parallax on a baseline of 2 AU. As we move out into the solar system, that baseline will expand by an order of magnitude and more, expanding by two or three orders of magnitude as we explore the Oort cloud. After the first interstellar voyages (presumably to Alpha Centauri) our baseline will have grown by more than five orders of magnitude over what astronomers use today. By the time we are ready to visit that star fifty light years out that Hemry mentioned, the error in our knowledge of its position will be considerably less than a trillion kilometers. Our knowledge of stellar positions will improve as we go, thereby ensuring that starships approaching an unvisited star will spend little or no extra time or propellant correcting positional errors: that's a point that Hemry should have made a little more clearly.

Next Hemry commented on the distortion of the starfield by relativistic aberration, though his suggestion that starships slow down to take bearings from a undistorted starfield is not a valid means of meeting the main challenge of relativistic astrogation. He does better when he says, "it may be possible to use a system to compensate for relativistic distortion and eliminate the need to slow down for bearings." Indeed so. Every starship's astrogation computer will have in its memory a three-dimensional chart of Sol, nearby stars, and some brighter distant stars (such as Betelgeuse and Rigel) to use as skymarks for astrogation. Using the mathematical properties of aberration, the computer can undistort the starfield so long as it knows the ship's heading (and a lost heading can be recovered easily enough by reference to the relatively undistorted starfield at low speeds and by exploiting the starbow effect at high speeds). From its manipulations, the computer will infer the ship's Lorentz factor and thence speed.

Determination of the ship's velocity would also be achieved by the obvious means of integrating over time the outputs from the ship's accelerometers and laser gyros (correcting for the growing effects of relativistic dynamics, of course) and by the less obvious means of comparing the images of selected stars taken through the ship's spectroscope with spectrograms made of those stars in the heliostatic inertial frame (actually quasi-inertial frame, but that's a quibble). An accurate knowledge of the ship's velocity is essential to astrogation, so I am astonished that Hemry did not devote more space to a discussion of these techniques.

And in discussing the working out of sailing directions, Hemry again refers to starships slowing down to take bearings, and then speeding up again. If it weren't for the references to GPS, I would have guessed that this article was written in the 1930's. I certainly don't feel that I have gained any new appreciation for the current state of the art (albeit of an art that is purely theoretical at this time). A good fact article often sends my imagination soaring: this one left it flamed out on the tarmac. Sure, to abuse an aging cliché, this is indeed rocket science, but it should not be difficult for those who know it to explain it, and to do so in a way that conveys some of the enthusiasm (enmemeasm?) that made the author care about the subject to begin with.

I can only hope that this article is an anomaly, because the horrible alternative is that it reflects slim pickings in the fact articles being submitted to you. Since the 1950's, I have enjoyed seeing the technological speculations that certain very creative people have spun out of modern science, and I hope that this

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particular feature of our culture is not dying. I hope to see again the kind of articles that boost my spirit into orbit and, on rare occasions, kick it into hyperspace.

Dennis Anthony
Los Angeles, CA

The author responds:

It's apparent that I should have clarified the meaning of "accuracy" in navigational use. Accuracy is a relative term, whose meaning depends on the degree of precision required. Someone accurately tabulating the human population need only fix an individual's location on Earth. Someone determining national populations only needs to know roughly where on Earth the person lives. But if you want to send that person a letter, you need to know exactly where their mailbox is located. And if you want to meet that person, you need to know within a few meters where they are at the moment you plan to see them.

In the same fashion, "accurately" determining a star's location outside of our immediate neighborhood doesn't mean you could send a letter there. In the case of the Hippacros satellite, scientists have been pleased to claim a "distance uncertainty of only five percent" in a few cases. This represents a high level of accuracy compared to past measurements, yet is far from what will be needed to plot a course to that star. Even using a satellite, the baseline is simply too short relative to the distance from the stars being measured for truly precise parallax calculations.

The same question of accuracy affects the use of inertial navigation systems. They will of course be used in future spacecraft because they can achieve relatively high degrees of accuracy compared to other positioning systems operating without external input. However, like anything else built by humans, inertial navigation systems have internal error. As a result, inertial navigation systems are routinely updated by external sources on Earth to correct for those errors.

For example, Litton advertises its new laser-gyro inertial navigation system to be used in the Air Force F-22 aircraft as having an accuracy "better than 0.8 nmi (nautical mile)/hr." In the very best case, using advertised maximum speed for the aircraft, that could be described as an error of very roughly one mile for every thousand miles traveled, or about .1% positioning error. (This is a very rough calculation because it is to some extent an apples and oranges comparison, as projected inertial navigation system errors are based not on linear distance covered but on accumulated error over time.)

Over interstellar distances, even such a slight error would produce large discrepancies. A light year is approximately 9.5 trillion kilometers. If only a .1% error could be maintained over that distance, it still produces a final position 9,500,000,000 kilometers off. Improve your system error by a few of orders of magnitude, to .0001%, and the final error would be a mere 9,500,000 kilometers. Of course, there aren't any stars within one light year, so distance covered and accumulated error would be much greater at the end of a journey to even the closest stars. Note that this isn't simply a matter of dramatically improving accuracy, but of maintaining that accuracy across immensely greater distances and much longer periods of time.

It is possible to correct for relativistic distortion. However, as the article pointed out, the precise amount of correction needed depends on your precise speed. If the speed input into the correction is off, then you will "see" the external object at a location which is off. A position determined by an erroneous location will itself have error, in the same manner as an attempt to reach for an object underwater is thrown off by refraction. Subsequent corrections, without an independent check on location, will compound the error as the system continues to correct the apparent view in accor-

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dance with speed estimates based on previous corrections. After light-years worth of internally-generated feedback, you might slow down to find the real view to be dramatically different from what your equipment had been telling you.

The same problem impacts on any other form of measurement, even doppler shifts. The tiniest errors in observational and corrective devices have huge potential results over the distances involved. Checking different methods against each other (inertial versus doppler shift versus apparent visual positions) can help identify discrepancies, but wouldn't tell you which specific method was off or by how much. All other things being equal, all different navigational methods used would probably be averaged together to produce a estimated position. Only when you reduce speed to a point where relativistic distortion is no longer a factor will you be able to determine how accurate the previous corrections were.

Pulsars can indeed serve as useful beacons for navigational positioning. Their pulses do slow over time, but at a rate which is known for each pulsar, so we could still compensate for rate changes. I'm frankly not enough of a physicist to know whether the pulses could be used to maintain calibration on clocks despite relativistic effects.

Of course, using pulsars wouldn't be the equivalent of a GPS. As Mr. Levites points out, we would determine bearings to different pulsars and establish a position by noting where those bearings cross. As with stars, the exact positions of the pulsars aren't known, so while the resulting position would be reliable, the degree of uncertainty would still be large by navigational standards. That would make pulsars great for identifying the area to look for a star, but not so good if you're trying to fix your position within a few hundred thousand kilometers.

John G. Hemry

Gentlemen,

The November 2000 "Brass Tacks" contained a letter from a reader who had "just finished the May 2000 issue of '*Analog*' and was quite surprised to find an astounding number of typographical errors." I was surprised that she was surprised. Years ago it seemed that the frequency of errors increased dramatically.

One of my pet peeves is the use of "they" instead of "he" as the third person singular pronoun in a case where the antecedent's sex is indeterminate. You have stated that you consider that to be a valid choice, part of the "fluid" nature of the English language. I'm sure other "errors" that annoy me fall in the same category.

Some errors are probably true "typos": a word dropped ("He gave the ball her"); a word repeated ("He gave the ball to to her"); a word repeated some distance from where it was meant to be ("He gave the to ball to her"); a word printed all on one line, but with a hyphen as though it had once spanned a line break.

Other errors strike me as being the fault of the author: Sometimes a sentence looks like the first half of one sentence and the last half of another, with a phrase common to both sentences in the middle, as if the author got distracted halfway through the sentence, and didn't bother reading more than the last few words he'd written before finishing the sentence. It bothers me when the subject and verb don't agree in number. When it's something like "the crew were ready", maybe it's more of the fluid, evolving nature of English. When it's something like "the report of long overdue but critical items were delivered", I think it's another case of a writer forgetting where he started.

I've wondered if this apparent increase in the frequency of errors was a result of your changing publishers, reducing the proofreading staff, getting more submissions in computer-readable

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form, or the retirement of one veteran linotype operator. I have to admit it could also be that the older I get, the slower I read, so I have more time to notice what was always there. Or maybe I'm just less tolerant of things with which I don't agree.

Jay Michael
Baltimore, Maryland

I haven't done a rigorous statistical study, but I do have more occasion than most people to dig around in old issues, from the magazine's entire history—and I see no evidence that there really are more errors than there used to be. However, in connection with your penultimate paragraph, I do know of one new cause of errors of the "forgetting where he started" category. Most writing is now done on computers, which make it very easy to change a sentence, sometimes quite radically, by a combination of deleting, adding, and moving; and it's not uncommon for a writer to do some of the stages of that process and forget to do others.

To Stan and Michael A. Burstein,

Two days ago, I received my November issue of *Analog*. I must express unbridled praise for "Kaddish for the Last Survivor." Over the years, I have become more and more discouraged by the state of education in this country in general, and as applied to the Holocaust. I'm dismayed to hear people, even those in their 60s, talk of the Holocaust as some sort of social glitch that we should put behind us. And the growing number of people who deny that it ever happened, who claim that it was just some political propaganda conspiracy, is truly frightening to a Jew. It's plain that, if that point of view persists and grows, then, undeniably, it *can* happen again and it can even happen here, in spite of how large and diverse this country is. And let's not forget that it has already happened to the Native Americans. These ignorant people need only talk, as I have done, with some of the GIs who were there on the scene first to open the camps and release the victims. Their stories can't be denied. But then the deniers in their self-imposed blindness would probably name them as part of the conspiracy anyway. Reading this story is a curiously timely event, given that only last weekend I was talking with a couple of friends, and one (an English woman in her 60s) actually said that there was no reason to keep reminding people of what happened there. I responded without hesitation that there was *every* reason. I didn't say more, but it gave me pause to think that here were two very intelligent people that I was talking with and I would never have expected either of them to come out with that kind of statement. Michael, I'm glad you made this story, and in a way that speaks to the problem so well. Stan, I'm grateful to you for publishing it as I'm sure many others are as well.

Chuck Karp
Fairfax, CA

Dear Stan,

I imagine you're going to draw a lot of flak as well as a lot of kudos for "Kaddish for the Last Survivor". Count me on the kudos side. But even I have to ask: is it Science Fiction?

Howard Mark

You bet it is! The memory technology is indispensable to keeping the memory alive. ■

A moment's insight is sometimes worth a life's experience

—Oliver Wendell Holmes

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UPCOMING EVENTS Anthony Lewis

18–20 May 2001
LEPRECON 27 (Arizona area SF conference) at Holiday Inn, Sunspree Resort, Scottsdale AZ. Guest of Honor—Michael A. Stackpole, Artist Guest of Honor—Stephen Hickman. Registration—$35 until 1 May 2001, $40 at door. Info—LepreCon 27, Box 26665, Tempe AZ 85285; phone—(480)945-6890; e-mail—lep26@leprecon.org; URL—www.leprecon.org/lep27/index.html

24–27 May 2001
SFRA 2001 (Academic SF) at Schenectady Ramada Inn & Convention Center, Schenectady NY. Guests of Honor—C.J. Cherryh, David Weber, Jane Yolen. Artist Guest of Honor—Vincent Di Fate. Registration—(SFRA members) $125 until 31 May 2001, $150 at door; non-members add $25. Info—Box 2085, Albany NY 12220; phone—(518)456-5242; e-mail—wombat@sff.net; URL—www.klink.net/~fcs/sfra2001.html

25–28 May 2001
BALTICON 35 (Baltimore SF conference) at Baltimore Omni Inner Harbor Hotel, Baltimore MD. Guest of Honor — Hal Clement. Artist Guest of Honor—Halla Fleischer. First Fandom Guest of Honor—David A. Kyle. Fan Guest of Honor—Robert Sacks (in memoriam). Registration—$40 until 30 April 2001, $45 at door. Info—Balticon 35, Box 686, Baltimore MD 21203-0686; (410)563-2737; e-mail—bsfs@balticon.org; URL—www.balticon.org.

25–28 May 2001
BAYCON 2001 (SF Bay area SF conference) at San Jose DoubleTree Hotel, San Jose CA. Guest of Honor—Rudy Rucker, Special Guest—Poppy Z. Brite. Registration—$65 until 30 April 2001, $70 thereafter. Info—www.baycon.org

25–28 May 2001
WORLD HORROR CONVENTION at Seattle Marriott Sea-Tac Airport, Seattle WA. Guests of Honor—Richard Laymon, Simon Clark; Editor Guest of Honor—Jessica Amanda Salmonson; Publisher Guests of Honor—Barbara & Christopher Roden; Artist Guest of Honor—Charles Vess; TM—Jack Ketchum. Registration—$90 until 15 November 2000, then more. Info—World Horror Convention—Seattle 2001, Box 5171, Bellingham WA 98227; (360)734-0919; e-mail—whc2001@uswest.net

30 August–3 September 2001
MILLENNIUM PHILCON (59th World Science Fiction Convention) at Philadelphia Marriott, Philadelphia, PA. Guests of Honor—Greg Bear, Stephen Youll, Gardner Dozois, George Scithers; TM—Esther Friesner. Registration—$160 after 30 September 2000; supporting $40. [These are the latest rates posted on the Internet as of the time this column went to press.] This is the SF universe's annual get-together. Professionals and readers from all over the world will be in attendance. Talks, panels, films, fancy dress competition—the works. Info—Philcon, Box 310, Huntingdon Valley, PA 19006. email—philcon2001@netaxs.com URL—http://www.netaxs.com/~phil2001. ■

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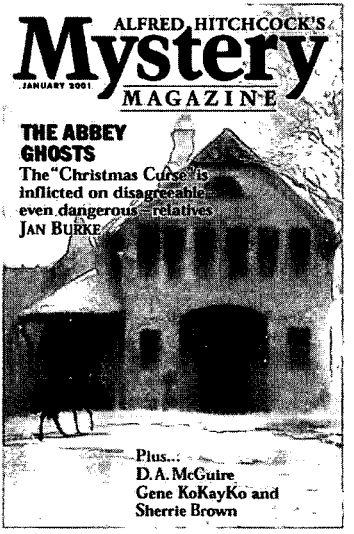

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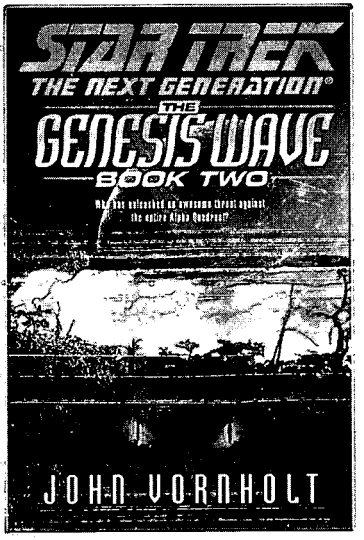

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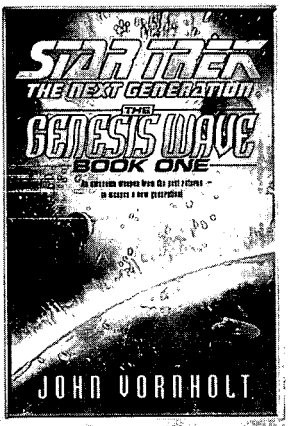

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